

E. Robertson

VEGETABLE INSECTS AND THEIR CONTROL

BY ALAN G. DUSTAN



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VEGETABLE INSECTS AND THEIR CONTROL

By ALAN G. DUSTAN, *Entomologist*

INTRODUCTION

In this bulletin an effort has been made to bring together the recently recommended control measures for the more important vegetable insects occurring in Canada. In a country as large as the Dominion and exhibiting such a wide variety of conditions between Nova Scotia and British Columbia, in many cases the same remedy has not been applicable throughout the whole area. Accordingly, in many cases, the control recommendations as given for any one species have been grouped under three headings, namely, Eastern Canada, Prairie Provinces and British Columbia. Such territorial divisions are based on the climatic or other conditions occurring in the respective areas. When only one remedy or set of remedies is suggested it may be assumed that this is suitable and effective in all areas of Canada where the species under discussion is present.

The treatment of vegetables attacked by insects is, on the whole, comparatively cheap, for materials, equipment and labour. This applies for the home garden as well as for the larger, commercial truck farms. In small gardens, although a hand duster is a convenience, effective control of certain insects can be brought about by the application of dusts when shaken through a burlap or cheesecloth bag. Furthermore, the amount of material used is exceedingly small and the outlay insignificant. For large areas, although the expense for machinery and material is much greater the increase in yield accruing from control operations will far more than pay the grower for his outlay of money and labour.

Where the distribution of the species included are under discussion mention is made only of their occurrence in Canada. It should be stated, however, that all the insects included in this bulletin occur also in the United States.

THE SIMPLICITY OF INSECT CONTROL

The control of most vegetable insects is not a very difficult or complicated matter if the grower will bear in mind one or two simple facts which can be quickly learned by watching the habits of the pests causing the damage. Insects, according to the type of injury they do, can be divided into two general classes; those known as biting insects, which in feeding actually bite a piece out of the plant attacked, and those known as sucking insects, which suck the juices out of the leaves or stems without noticeably changing their outline. Biting insects, as a class, are controlled by covering the plants on which they are feeding with a poison, such as arsenate of lead. This is taken into the stomach with the food and subsequently causes death. Sucking insects, on the other hand, inasmuch as they do not take pieces of plant tissue into the intestine, cannot be killed by a stomach poison but must themselves be covered by a spray or dust which will either kill them by contact or else give off fumes which will destroy them when taken into the respiratory system. Caterpillars, such as cutworms, belong to the first class of insects, while aphids, plant bugs, leafhoppers, etc., come into the second class.

For biting insects three poisons are commonly recommended, arsenate of lead, arsenate of lime and Paris green. Sucking insects are customarily controlled by nicotine sulphate, either in liquid or dust form. So that, speaking generally, all the grower has to do when his crops are being attacked by insects is to determine whether the injury is being caused by a biting or sucking form

and to apply either a stomach poison, such as has been mentioned above, or nicotine sulphate. There are of course exceptions to this general rule but the great majority of our most troublesome insects can be controlled either by an arsenical or by nicotine sulphate.

In the carrying out of control work and the application of sprays and dusts there are available many types and makes of suitable spraying and dusting machines. Under small garden conditions, the sprayers and dusters shown in figures 1, 2, 3 and 7 will be found very effective. In larger truck gardens, the barrel type of sprayer (figs. 4 and 5) will give good results or, if dusting is preferred, a rotary hand duster (fig. 8) can be successfully used. Where commercial vegetable farms are being treated, power dusters or sprayers are recommended in order that crops may be quickly and effectively protected from the attacks of injurious insects.

INSECTICIDES

A short description of some of the more commonly used insecticides is given for purposes of comparing their respective strengths and costs. Prices quoted were secured from one of the larger seed houses making a practice of handling these materials in Eastern Canada. These should apply fairly accurately to most parts of Canada but may be somewhat too low for the Prairie Provinces and British Columbia. In discussing the different poisons, mention is made of foliage injury, since some arsenicals, when used alone, have a tendency to burn the leaves and even the tender tips of the plants. Such injury usually causes a discoloration and browning of the parts affected and in severe cases the leaves drop off and death of the plant results. For this reason care must be exercised in the selection and proper use of the different arsenicals. The addition of hydrated lime to sprays containing poisons likely to cause burning is recommended, in that this material counteracts any tendency to injury.

STOMACH POISONS

Arsenate of Lead.—One of the most commonly used poisons, arsenate of lead has very many things in its favour as an insecticide. It is purchased now as a white powder although previously it was, also, available in paste form. It has the advantages of being safe on most types of foliage, adheres well to leaf surfaces, settles slowly in water suspension and can be safely combined with most other insecticides and fungicides. Due to its lightness and its finely divided state, it is an excellent arsenical to use in dusts. Its chief drawbacks are that it kills rather slowly and is comparatively expensive. In spraying mixtures it is commonly used at the rate of $1-1\frac{1}{2}$ pounds to 40 gallons of water, although if the need arises it may be used at two or three times that strength with safety. In dusts for vegetable insects, it is customarily diluted with 6 to 8 parts of hydrated lime, although no injury will result where a much stronger mixture is used. Arsenate of lead contains 20-21 per cent of metallic arsenic, the killing principle. It costs between twenty and thirty cents per pound in small lots.

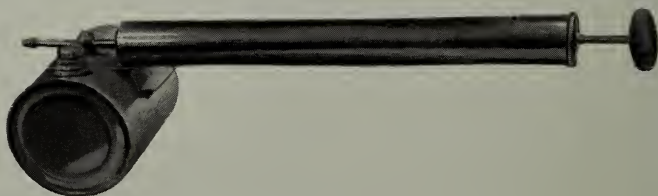


Fig. 1—Small type of hand sprayer (original).

Arsenate of Lime (calcium arsenate).—Arsenate of lime, or calcium arsenate, is a fine, flocculent, white powder which is gradually coming into popularity as an insecticide. Compared with arsenate of lead it has the advantages of being cheaper, of having a higher metallic arsenic content and of killing insects more rapidly. On the other hand, it is more likely to burn the foliage, has to be used more carefully and does not adhere so well to the plants. When used alone as a spray, it is customary to add sufficient hydrated lime to counteract any possibility of burning. One pound of arsenate of lime is equivalent to $1\frac{1}{2}$ pounds of arsenate of lead in killing value. As a spray it should be used at the rate of $\frac{3}{4}$ of a pound to 40 gallons of water to which has been added 2 pounds of hydrated lime. In dusting with this material, dilute it with 10 parts of hydrated lime. Arsenate of lime contains 26-28 per cent of metallic arsenic. It costs eighteen to twenty cents per pound in small lots.



Fig. 2—Bucket pump (original).

foliage unless care is exercised in its use. Due to the large size of its particles it does not remain in suspension for any length of time and easily washes off the foliage after spraying. It costs over twice as much as arsenate of lime and considerably more than arsenate of lead. To minimize the possibility of burning, hydrated lime should always be added to a spray containing this insecticide. It is used in spray mixtures at the rate of $\frac{1}{2}$ pound to 40 gallons of water and as a dust should be diluted with 15-20 parts of hydrated lime. Paris green contains about 41 per cent metallic arsenic. It costs thirty-five to forty cents per pound.

Magnesium Arsenate.—Magnesium arsenate is used as a control for the Mexican bean beetle, chiefly because it is safe to use on bean foliage which is very sensitive to arsenical sprays. This poison is sold in the form of a white powder and is applied in liquid and dust form. It kills quickly, adheres to the foliage well and when in suspension settles rather slowly. In sprays it is customarily used at the rate of 1 pound to 40 gallons. Magnesium arsenate costs slightly more than arsenate of lead.

Paris Green.—Paris green is one of our oldest poisons and even to-day is used extensively against the potato beetle. Its chief recommendation is that it kills the insects rapidly. It is one of our most unsafe insecticides and readily burns



Fig. 3—Knapsack sprayer (original).

White Arsenic.—This arsenical is used chiefly in baits where there is no danger of injury to foliage by burning. On the prairies, where the relative humidity is low, it is used with safety as a dust diluted with hydrated lime. In Eastern Canada it cannot be employed in either spraying or dusting operations. White arsenic has a metallic arsenic content of about 73 per cent and costs from twelve to fifteen cents per pound.

Sodium Fluosilicate.—This material comes in the form of a white powder and is customarily used as a dust diluted with 5 to 9 times its bulk of hydrated lime. It is becoming more popular as an insecticide for use against large, resistant insects such as blister beetles, Mexican bean beetle, etc. It is comparatively cheap but unfortunately is not as yet readily available in Canada.

CONTACT INSECTICIDES

Nicotine Sulphate.—This is the most commonly used contact insecticide. In appearance, nicotine sulphate resembles dark molasses and as purchased today usually contains 40 per cent nicotine as the alkaloid. It does not burn

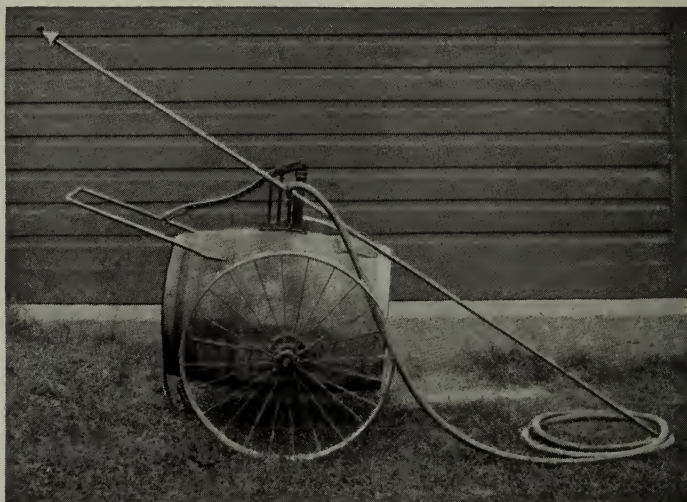


Fig. 4—Barrel sprayer suitable for use in small gardens (original).

foliage and can be safely mixed with combination sprays containing arsenicals and fungicides. It is commonly used as a spray in the strength of $\frac{3}{8}$ of a pint to 40 gallons of water. As a dust, 5 pounds of nicotine sulphate are usually mixed with 95 pounds of hydrated lime. The amounts of the insecticide can be increased with safety in both sprays and dusts. The addition of 2 pounds of soap to each 40 gallons of spray increases the effectiveness of the nicotine. Nicotine sulphate is rather expensive, the material selling in 10 pound tins at \$12.50. Where large amounts of this insecticide are being used growers are strongly advised to purchase it in large tins, since the price increases inversely with the size of the container. In this bulletin, unless otherwise indicated, nicotine sulphate will mean nicotine sulphate containing 40 per cent nicotine as the alkaloid.

Pyrethrum.—This insecticide comes in the form of a pale brown to yellowish powder and consists of the pulverized flower heads of certain chrysanthemum species which grow chiefly in Balkan countries but are now being grown on this continent experimentally. It is used commonly on vegetables or fruits which are soon to be eaten, since although deadly to insects it is non-toxic to human beings. This is its most outstanding feature. It deteriorates very rapidly when

exposed to air and for this reason purchasers should be sure that it is fresh and has been stored in air tight containers. It can be used as a dust either pure or diluted with 4 times its weight of cheap flour. As a spray it is commonly used at the rate of 1 ounce per gallon of water. Pyrethrum powder costs about eighty cents per pound.

Lubricating Oil Emulsion Spray.—In vegetable insect work this has been used as a spray against the onion maggot. Directions for mixing a 2½ per cent oil spray, which is the recommended strength, are as follows:—

Mix a gallon of Bordeaux mixture by first dissolving 2 ounces of bluestone in a gallon of water and then adding 2 ounces of hydrated lime to the solution. This should be thoroughly stirred and poured into a pail containing a gallon of the oil. By means of a bucket pump or other small sprayer, pump the liquid



Fig. 5—Barrel pump mounted on cart (original, from photo by R. C. Treherne).

back] upon itself until a perfect emulsion of the oil and Bordeaux is secured. This should take about 3-5 minutes and can be tested by pouring a small quantity into water. If the emulsion mixes perfectly with the water and leaves no oil droplets on the surface it is ready to use, but should free oil be present further agitation will be necessary. When the oil is thoroughly emulsified, mix the 2 gallons with 38 gallons of soft water and the spray solution is ready for use. If the water is hard the emulsion should be diluted in 38 gallons of 4-4-40 Bordeaux mixture, otherwise there is danger of the oil separating out and the plants being injured by the spray.

Where a power sprayer is employed the oil can be emulsified by simply pouring the correct amount into the tank filled with 4-4-40 Bordeaux mixture and allowing the agitator to run for 5 minutes. A perfect emulsion results which can be used with safety on onions. 4-4-40 Bordeaux mixture is made by adding 4 pounds of copper sulphate and 4 pounds of hydrated lime to 40 gallons of water, as described on page 8.

Kerosene Emulsion.—This is a contact spray and is composed of the following ingredients:—

Kerosene (coal oil).....	2 gallons
Rain water (hot)	1 gallon
Soap.....	½ pound

To prepare, cut the soap into fine shavings and dissolve in the correct amount of hot water. Pour the mixture into the kerosene and, by means of a syringe or small sprayer, pump the liquid back onto itself for at least 5 minutes or until a thick, creamy emulsion results. This constitutes the stock solution and when required for use it should be diluted with 9 times its measure of warm water. The stock solution, when properly made, will keep for a number of days if kept from the air.

SPECIAL INSECTICIDES

Corrosive Sublimate.—This material is used almost exclusively as a control against the cabbage maggot. It usually comes in the form of a heavy white powder costing about \$2.50 per pound, but can also be purchased in tabloid form. It is a deadly poison and is very corrosive to metal containers. It is recommended at a strength of 1 ounce to 10 gallons of water. A full discussion regarding the manner of its use will be found in the section dealing with the cabbage maggot.

SPREADERS

Certain plants, such as cabbages, cauliflowers, onions, beets, etc., the leaves of which are covered with a thin waxy coating are very difficult to spray effectively, due to the fact that the liquid does not spread evenly over the foliage but collects in drops and frequently runs off. This tendency can be partially corrected if some spreader is mixed with the spray. The two most commonly known spreaders in use to-day are soap and calcium caseinate.

Common laundry soap serves the purpose well and is used at the rate of 2-4 pounds per 40 gallons of spray. It should be cut up into fine shavings, dissolved in hot water and then added to the spraying solution.

Calcium caseinate is prepared commercially from dried casein which is mixed with lime. It is a creamy coloured granular substance resembling corn meal in appearance. It is comparatively cheap and is used at the rate of $\frac{1}{2}$ a pound to 40 gallons of spray. The calcium caseinate should first be mixed into a thin paste with cold water and when the substance has thoroughly dissolved further diluted and finally poured into the spray tank.

FORMULAE FOR COMMONLY USED MIXTURES

Bordeaux Mixture.—Bordeaux mixture, although primarily a fungicide, is also used as a control for many species of flea beetles and some leaf hoppers. It is practically always used as the basic liquid when spraying for potato beetles since it is the standard remedy for many important potato diseases. Bordeaux mixture is made by mixing copper sulphate (bluestone), hydrated lime and water together in the following proportions:—

Copper sulphate (finely ground).....	4 pounds
Hydrated lime.....	6 pounds
Water.....	40 gallons

The method is greatly simplified if finely ground copper sulphate and hydrated lime are used. After the spray tank has been filled with water, the engine is started and the correct amount of finely ground copper sulphate gradually added. With the agitator running the fine powder will be thoroughly dissolved in 5 minutes. In the meantime the hydrated lime is placed in a large pail and slowly stirred with a stick while sufficient water is added to fill the container. After thorough mixing, the liquid is then gradually added to the now dissolved copper sulphate in the spray tank, while the engine and agitator continue to run. This proceeding is repeated 2 or 3 times until all the hydrated lime, with the exception of the insoluble foreign matter in the bottom of the pail, has been carried over into the spray machine. The Bordeaux mixture, which is pale blue in colour, is now ready to apply. Where small hand sprayers are used the method is exactly the same except that the agitation of the liquid in the sprayer will have to be done by means of a flat stick in the absence of an engine and mechanical agitator.

Nicotine Dusts.—Nicotine dusts, as used against sucking insects, are gaining in popularity on account of the comparative ease with which they can be applied and their greater effectiveness as compared with liquid applications. Nicotine dusts are made by mixing nicotine sulphate with hydrated lime, the

strength of the dust, of course, being dependent upon the amount of the insecticide added. The most generally used dust is composed of 5 pounds of nicotine sulphate mixed with 95 pounds of hydrated lime, giving approximately a 2 per cent nicotine dust. However, when a stronger dust is required the amount of nicotine sulphate may be increased and the hydrated lime decreased proportionately. Nicotine dusts should be used as soon as mixed for best results, but if it is necessary to store them they should be kept in air tight containers, since they quickly lose their strength if exposed to the air.

In preparing nicotine dusts, or dusts of other types mentioned later, the process can be speeded up and made much more effective if a barrel mixer is



Fig. 6—Simple type of dust mixer (original).

used. This consists of a barrel with an axle run through it from end to end which is slightly off centre. This axle has a handle at one end to facilitate turning and is mounted on a rough frame strong enough to support the barrel when partly filled with hydrated lime. A removable door is fitted in the side of the barrel by means of which the mixer is loaded. Several round stones about the size of a man's fist are placed inside. These have both a pulverizing and mixing effect on the dusts. The hydrated lime and nicotine are added, the door closed and the barrel turned slowly for five minutes, by which time a thorough mixing of the contents will have taken place. The dust is then removed and either used immediately or stored in tight containers.

Arsenical Dust.—In dusting with stomach poisons, either arsenate of lead or arsenate of lime can be used, depending upon the preference of the grower. In either case hydrated lime is used as the carrier. For arsenate of lead dusts, 10-15 pounds of poison should be mixed with 90 or 85 pounds of hydrated lime. In the case of arsenate of lime dusts 8-10 pounds of the arsenical are added to 92 or 90 pounds of the carrier. The strength of the dust in cases will vary with the insect being combated. Arsenical dusts should be mixed in the barrel mixer and will not deteriorate when exposed to the air.



Fig. 7—Small type of hand duster (original).

Bordeaux Dust.—In combating flea beetles or in treating potatoes for insect enemies, a Bordeaux dust may be used in place of the regular poisoned Bordeaux spray. Such dusts can be purchased from all commercial spray companies ready mixed or they may be prepared on the premises providing a good mixing machine is available. The following is the standard formula for Bordeaux dust:—

Copper sulphate (dehydrated and ground very fine).....	12 pounds
Hydrated lime.....	80 pounds
Arsenate of lime.....	8 pounds

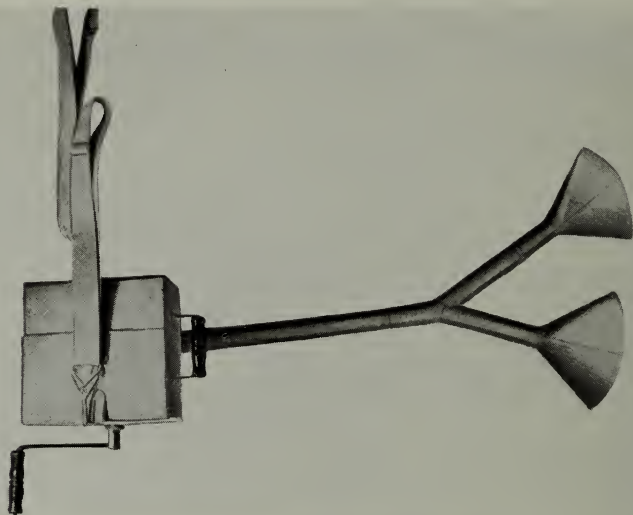


Fig. 8—Rotary hand duster (original).

The amounts of copper sulphate or arsenate of lime or both can be increased to suit the insect, but this must be compensated for by reducing the amount of hydrated lime to a corresponding extent so as to keep the total at 100 pounds.

TABLE I

COMPARISON OF THE THREE ARSENICAL OR STOMACH POISONS IN COMMON USE AT THE PRESENT TIME FOR BITING INSECTS*

POISON	COST	ADHER- ENCE TO PLANT	BURNING	SUSPENSION	KILLING	METALLIC ARSENIC (As)	WATER SOLUBLE ARSENIC
Arsenate of lead..	18c.-30c. per lb.	Good	Slight	Settles slowly	Slow	20%-21%	0.04-0.51
Arsenate of lime.	12c.-20c. per lb.	Fair	Some	Settles slowly	Rapid	26%-28%	0.05-1.06
Paris green.....	35c.-40c. per lb.	Poor	Burns readily	Settles rapidly	Very rapid	41%-43%	0.72-1.50

All packages containing insect poisons must have printed thereon the antidote and net weights as well as the guaranteed analysis in the form prescribed by regulations. In buying arsenical poisons it is of importance to the grower to note the proportion of metallic arsenic present. While the water soluble arsenic content has some value as a fungicide and a slight insecticidal value, it should be present only in the minimum amount; otherwise foliage injury may,

*Prepared by R. H. Painter, Entomological Branch, Ottawa.

and usually does occur. The metallic arsenic is the active killing agent and should constitute at least 20 per cent in the case of arsenate of lead, 26 per cent in calcium arsenate and 40 per cent in the case of Paris green.

For the convenience of growers the following charts have been prepared outlining the amounts of different stomach poisons to be used in sprays and dusts when mixed with varying amounts of water and hydrated lime for the control of biting insects. Special recommendations, where an abnormally strong concentration of the poison is needed to bring about control, are discussed individually under the species involved.

TABLE II

AMOUNTS OF EACH STOMACH POISON TO BE MIXED WITH VARIOUS QUANTITIES OF WATER FOR BITING INSECTS*

Water	1 gallon	5 gallons	20 gallons	40 gallons	80 gallons	120 gallons
Arsenate of lead.....	3½ teasp.	¼ lb.	½ lb.	1 lb.	2 lb.	3 lb.
†Arsenate of lime.....	3 teasp.	1½ oz.	¾ lb.	¾ lb.	1½ lb.	2¼ lb.
Paris green.....	2 teasp.	1 oz.	4 oz.	½ lb.	1 lb.	1½ lb.

AMOUNTS OF STOMACH POISONS TO BE MIXED WITH HYDRATED LIME AS A DUST FOR BITING INSECTS

Hydrated lime	1 pound	5 pounds	10 pounds	50 pounds	100 pounds
Arsenate of lead, 1-7.....	2 oz.	10 oz.	1½ lb.	6¼ lb.	12½ lb.
Arsenate of lime, 1-10.....	1½ oz.	7¼ oz.	14½ oz.	4 lb. 8 oz.	9 lb.
Paris green, 1-15.....	1 oz.	5 oz.	10 oz.	3⅞ lb.	6¼ lb.

8 teaspoons make 1 fluid ounce.

2 tablespoons make 1 fluid ounce.

TABLE III

AMOUNT OF NICOTINE SULPHATE TO BE ADDED TO VARIOUS QUANTITIES OF WATER AND LIME TO MAKE UP SPRAYING AND DUSTING MIXTURES*

Water	1 gallon	5 gallons	20 gallons	40 gallons
¾ pt.—100 gal.....	1½ teasp. 1 oz. soap	6 teasp. ¼ lb. soap	3 oz. 1 lb. soap	6 oz. 2 lb. soap
1 pt.—100 gal.....	1¾ teasp. 1 oz. soap	8 teasp. ¼ lb. soap	4 oz. 1 lb. soap	8 oz. 2 lb. soap
1½ pt.—100 gal.....	2¾ teasp. 1 oz. soap	12 teasp. ¼ lb. soap	6 oz. 1 lb. soap	12 oz. 2 lb. soap

NICOTINE DUST (HYDRATED LIME CARRIER)

Hydrated lime	5 pounds	25 pounds	50 pounds	100 pounds
Approx. 3% dust.....	6 oz.	1¾ lb.	3¾ lb.	7¼ lb.
Approx. 5% dust.....	9½ oz.	3¼ lb.	6½ lb.	12½ lb.

Nicotine dusts may be combined with arsenate of lead dusts for such cases as an attack of cabbage aphid and imported cabbage worm. To make such a combination dust add the nicotine sulphate to the arsenate of lead dust in the same amounts as recommended for a nicotine dust alone.

†An equal quantity of hydrated lime should be added to Paris green and arsenate of lime.

*Prepared by R. H. Painter, Entomological Branch, Ottawa.

GENERAL DISCUSSION OF SPRAYING AND DUSTING OPERATIONS

Considerable discussion has arisen in the past concerning the comparative merits of spraying and dusting for insect control. Much, of course, will depend upon the conditions with which each grower is faced as to what method is adopted. For instance, if the water supply is inadequate, spraying would never even be considered. On the other hand, if a man already owned a good sprayer it might be unwise to go to the expense of buying a duster.

The following tables will set out the chief advantages and disadvantages of spraying and dusting:—

ADVANTAGES

Spraying

Insecticides adhere better to foliage.
More even distribution of insecticides.
Cheaper for materials.

Dusting

No drain on water supply.
Loaded duster much lighter than sprayer.
Dust applied more rapidly.
Labour charge less.
Cost of machinery less.
Work done in early morning or late evening, hence no interference with other work.
Cleaner, from operator's viewpoint.

DISADVANTAGES

Spraying

Large amount of water used, serious if water supply limited.
Loaded sprayer very heavy, cutting into wet or deeply cultivated soil.
Comparatively slow.
Labour charge high.
High power machines very expensive.
Disagreeable and dirty both to prepare and apply.

Dusting

Uneven distribution of insecticides.
Insecticides wash off more easily.
Costs more for materials.

In vegetable insect work the application of arsenicals in dust form is becoming more popular every year. This is chiefly due to the fact that dusting is so much quicker and easier than spraying, not only in so far as the actual application of the materials is concerned but also in regard to the preparatory work which must always be done prior to either operation. Many growers would dispense with control operations rather than go to the trouble of mixing up the spray, filling the sprayer and applying the material. However, there are two distinct and important arguments in favour of spraying, namely, that the foliage is more evenly and thoroughly covered where the insecticides are applied in liquid form and that the materials adhere longer and are less likely to be washed off by rains. These points should not be overlooked.

In the application of insecticides, whether in dust or liquid form, a few general principles should be considered. It is very important that control operations should be started early. Many growers make the mistake of delaying spraying or dusting until the insects have reached a considerable size and until a large amount of damage has been done. This is a mistake, for not only has the crop been severely injured by that time and much loss already incurred, but the insects are always far more difficult to kill when partially or fully grown than when small. The plants should be watched carefully and the first application made upon the first sign of injury. Repeated sprayings or dustings should be made, in general, at intervals of a week as long as feeding continues and injury is noticeable.

In applying insecticides it should always be borne in mind that good results will only follow when thorough work has been done. This means covering every portion of the plant evenly and completely, not forgetting the under surfaces of the leaves, since many insects feed there in preference to any other situation on the plant. In order to do this effectively, angle nozzles are used. These are carried close to the ground and throw the spray or dust upward.

Do not try to economize on materials. To do thorough work liberal applications will have to be made, but the returns warrant it. In spraying field crops, such as potatoes, beans, etc., 75-150 gallons per acre should be used at each application, the amount varying with the size and development of the plants. In dusting, the amount varies with the concentration of the dust as well as with the size of the plants. In cases where the arsenical makes up only 8-10 per cent of the dust, 40-50 pounds per acre at each application is the correct dosage. If the percentage of poison is increased, however, the amount per acre can be reduced proportionately.

In spraying, good pressure should be used to insure driving the spray into the centre of the plants. This is very important in cases where sucking insects are being combated by a contact spray. The attacks of many sucking insects cause the leaves to roll up, forming a shelter in which the insects hide. To reach such insects a driving spray with a pressure of 125-150 pounds per square inch at least is necessary. Spray after rather than before a rain and delay making the application until the foliage is dry. However, it should be borne in mind that once a spray has had an opportunity of drying thoroughly it can withstand considerable rainfall and still retain its killing power.

Dusting with arsenicals is best done in the early morning and late evening when the air is calm and the plants are wet with dew. The latter point is most important as dusts do not adhere nearly so well if applied to dry foliage. A light breeze does not seriously interfere with dusting, but the operation should always be delayed if a strong wind is blowing. Favourable conditions are frequently encountered after a shower during the day, when there is a temporary calm.

Dusting with contact dusts, on the other hand, should always be done during the hottest part of the day, and, if possible, on a day when there is little wind blowing. If the temperature is below 70° F. in the shade, operations should be delayed until more favourable weather. This is very important and applies to contact sprays as well.

When field crops are being treated with contact dusts, much better control is effected if a cotton sheet is attached to the boom and allowed to drag over the tops of the plants. This sheet should be made of some light material, such as factory cotton, since a heavier cloth might injure the plants. It should be the full width of the boom and should trail out behind for a distance of 25-30 feet. A sheet of this description has the effect of holding down the dust and concentrating it around the insects for a longer period of time. It increases the value of the control very materially and should be adopted by all large growers.

CLEAN CULTURE AND OTHER PRACTICES WHICH HAVE A BEARING ON INSECT CONTROL

In insect control work there are many helpful steps which the gardener may take, quite apart from the actual spraying and dusting with arsenicals or contact insecticides, which will assist very greatly in checking the increase and development of insects. It has been found of great assistance to have all plants in a healthy and vigorous condition. Induce rapid growth, particularly when the plants are small, by thorough cultivation and the liberal use of suitable fertilizers. The use of good seed, showing a high percentage of germination is recommended. By having strong, healthy and rapidly growing plants it will be found that they are much better able to withstand the attacks of insects and even at times to outgrow quite severe injury.

Fall ploughing assists in killing many insects which winter over in the soil. Frequent freezing and thawing is much harder on all insect life than continued steady cold. By bringing the insects up to the surface through ploughing they are placed in an ideal position to be most affected by the frequent temperature changes common during autumn and spring.

A large number of very important vegetable insects pass the winter in, or attached to, their favorite host plants. If these plants, after harvest, are allowed to remain in the field until spring, it can be readily seen that the insects when they emerge will be ideally situated to attack the new crop. Furthermore, many other forms which do not actually hibernate in the plants have the habit of hiding beneath rubbish and debris in the gardens during the cold months of winter. Crop remnants allowed to remain in the fields afford most suitable wintering quarters. For this reason it is most important that the old plants be carefully removed from the fields as soon as the crop is harvested. If possible the remnants should be burned, fed to stock, buried or ploughed under. If this is not possible they should be hauled to some suitable dump as far from the fields as possible, so that when the hibernating insects emerge in the spring there will be little danger of the new crop becoming infested from this source. The cleaning up of refuse from the fields in autumn is most important and should never be neglected.

Some vegetable insects have the habit of spending the winter on weeds surrounding the garden. For this reason it is a wise precaution, wherever possible, to burn over all wasteland in the vicinity of vegetable gardens. This should be done preferably in late autumn, but if this is not possible, in early spring before insect activity commences. This practice will destroy most insect stages which may be present either on the weeds or grasses or in the old decaying vegetation at the soil surface.

Many growers, owing to the fact that they are unprepared, lose a large percentage of their crop from insect attack before they are able to get their spraying or dusting equipment into good working condition or while they are spending time buying insecticides. This can all be overcome by a little care and attention in winter or early spring when time is not at a premium. During the slack season all spraying and dusting equipment should be carefully checked over and repaired. Moving parts should be oiled and greased and rubber hose renewed where necessary. An actual test of equipment should be made to ensure that it will render efficient service when the time comes to put it to its proper use. A stock of standard insecticides should be purchased in the spring by every grower, the amount in each case to be governed by his acreage and by experience from previous years. Such a list should include the following materials: (1) arsenate of lead (or, if preferred, calcium arsenate or Paris green), (2) nicotine sulphate, (3) copper sulphate (bluestone) finely ground, (4) hydrated lime, (5) corrosive sublimate and, in the West, (6) copper carbonate and (7) white arsenic. If the onion maggot is an important annual pest, a supply of lubricating oil should be purchased and where cutworms are expected to be a menace bran should be added to the list. Such a supply of materials will meet the need of the average grower and should always be on hand for emergencies. If kept in a dry place they will not deteriorate and can be carried over, when not used, from one season to another.

GENERAL METHODS OF CONTROL FOR APHIDS AND FLEA BEETLES

APHIDS

Aphids, or plant lice, of different species are to be found attacking almost every vegetable or field crop in Canada. They are sucking insects and as such are not amenable to control by the use of a stomach poison, such as arsenate of lead. The insecticide most commonly used against these insects is nicotine

sulphate. It can be used either as a spray or dust, depending on the preference of the grower; but, as a general rule, this material in dust form is more effective against aphids than when applied as a liquid.

For spraying, use nicotine sulphate at the rate of $\frac{3}{8}$ of a pint to 40 gallons of water to which has been added 2 pounds of laundry soap. Where dusting is preferred, a 2 per cent nicotine dust is effective for most species. Such a dust is prepared by mixing 5 pounds of nicotine sulphate in 95 pounds of hydrated lime as directed on page 9.

Spraying or dusting with nicotine should be done during the hottest part of a calm day for most effective results. Use plenty of material and pay special attention to the undersides of the leaves, since aphids are usually found there. An angle nozzle is recommended which will throw the spray or dust upward from underneath. In dusting large plots with a power duster a cotton trailer should be dragged behind the machine for the purpose of holding down the dust and concentrating it around the insects for a greater length of time. This is discussed on page 13. Spraying or dusting should be carried on at weekly intervals until the infestation is checked.



Fig. 9—Aphids feeding on the underside of a leaf (after Gibson and Ross).

FLEA BEETLES

Flea beetles, various species of which infest potatoes, turnips, tomatoes, cabbage, etc., in general can be best controlled by spraying the infested plants with Bordeaux mixture. This material acts as a repellent to the beetles and has the effect of driving them away to unsprayed plants. The ordinary 4-6-40

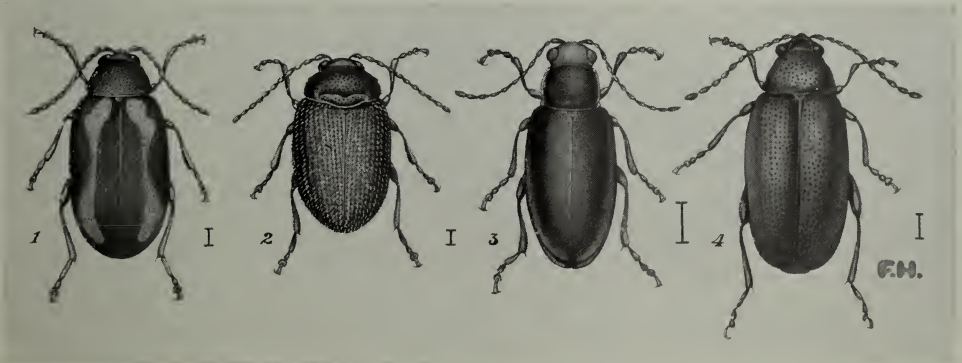


Fig. 10—(1) striped flea beetle; (2) potato flea beetle; (3) red-headed flea beetle; (4) cabbage flea beetle (after Gibson).

Bordeaux should be applied just as soon as the work of the insect becomes evident. Spray thoroughly, covering both the upper and lower surfaces of the leaves. The application should be repeated in from 10 to 12 days. If other biting insects feeding on the same crop need attention, lead arsenate or arsenate of lime may be added to this spray without detracting from its effectiveness. Directions for the preparation of Bordeaux mixture are given on page 8.

GENERAL FEEDERS

CUTWORMS

Practically all field and garden crops are subject to the attack of cutworms. The type of injury caused by these insects varies considerably with the species responsible for the damage. Most commonly, cutworms while feeding at the ground level cut through the stem of the plant and cause it to fall over and eventually



Fig. 11—Cutworms at base of badly injured corn plant (original, from photo by P. C. Rollins).

die. Climbing cutworms ascend the plant and feed on the foliage while other species attack the root system. Most cutworms are nocturnal in habit, hiding in the soil by day and emerging in the evening to feed upon their favourite host plants. These insects are among the most important, from the viewpoint of the gardener and the vegetable grower. They do an immense amount of damage annually, the great bulk of which takes place in the spring and early summer months when the plants are young.

Cutworms as a group are rather stout, hairless caterpillars, varying in length, when full grown, from $1\frac{1}{2}$ to 2 inches. The colour varies considerably with the species, from nearly white in some forms to gray, brown, red and even black in others. Cutworms are frequently ornamented with different coloured stripes and markings which may be present on the back or sides, or both. They usually lie coiled up when at rest.

The winter is passed in different stages, varying with the species. The majority of cutworms hibernate in the soil either as eggs or as larvae. Some overwinter in the adult or pupal stage, the moths hidden away in protected situations and the pupae beneath the soil surface. Feeding commences in the spring, those forms wintering as larvæ attacking cultivated and wild plants as soon as growth starts. Feeding continues until the cutworms reach their full size when they enter the soil to pupate. The number of generations each season also varies with the species.

These insects are very widely distributed throughout Canada.

CONTROL

Under garden conditions cutworms can be controlled by a poisoned bait which is broadcast over the soil either before the seeds are planted or prior to the setting out of the young plants. The bait used is composed of the following ingredients:—

Bran.....	25 pounds
Paris green.....	$\frac{1}{2}$ pound
Molasses.....	1 quart
Water (about).....	$2\frac{1}{2}$ gallons

The dry and wet ingredients should be mixed separately and then brought together in a tub or other large receptacle and the whole thoroughly stirred. When fully mixed the bait should be of the consistency of wet sawdust and should crumble and slip easily between the fingers. Do not have it too wet since, if sloppy, it is impossible to spread it thinly and evenly over the ground.

Eastern Canada.—A few days before seeding or transplanting, spread the bait evenly and thinly over the surface of the ground. It is most important that this be done in the evening and only following a warm day, since if the night is cold little feeding will take place and the bait will be wasted. Use about 10-15 pounds of bait per acre at each application. If a second application is necessary this should be made 3 or 4 days after the first. When plants are attacked, a teaspoonful of this bait placed around the base of each plant in the evening will give good results.

Never leave the bait in a place accessible to live stock or children as it is a deadly poison. If broadcast thinly the bait is not dangerous in the field, except to poultry.

Prairie Provinces.—On the prairies the bait should be spread after seeding but before any plants are up. In the case of transplants, the control should be applied 2 or 3 days prior to the setting out of the plants. Furthermore, the ground to be treated should first be watered but allowed to warm up again before the poisoned bran is broadcast. In market gardens the growers usually irrigate prior to applying the cutworm control.

British Columbia.—Control is much the same as in Eastern Canada. In this province, however, the addition of 3 or 4 lemons to the bait is advocated. Both the juice and ground-up pulp and rind are used in this connection, these being added to the liquid part of the bait during its preparation.

ARMYWORMS

The true armyworm (*Cirphis unipuncta* Haw.), unlike its near relatives the cutworms, does not occur every year, but sudden and often serious outbreaks appear at irregular intervals. Grasses are the natural food of these insects, but in years of abundance if these plants are destroyed the armyworms migrate to grain fields and gardens and consume practically every green thing encountered. In years of heavy infestation they assume the marching habit. Migration and feeding usually take place at night and as a result fields are often practically

destroyed before the growers are aware of the presence of the insects. In the case of armyworms, all feeding is done above the ground level, the plants not being cut down as is the custom of cutworms.

Armyworms are about one and a half inches long when full grown. They are stout, hairless caterpillars, dark green in colour and with 3 stripes extending down each side. They hibernate in a partially grown state in the soil and with the return of warm weather emerge to feed upon grasses. When full grown the larvae pupate in the soil and the dark brown moths appear in June, to deposit their eggs on grasses. Caterpillars hatching from these are responsible for serious damage to crops. Moths appear again in the autumn and deposit eggs from which the overwintering larvæ are produced.



Fig. 12—Armyworms in control ditch (after Gibson).

On the prairies the army cutworm (*Chorizagrotis auxiliaris* Grote), the Bertha armyworm (*Barathra configurata* Walk.) and the beet webworm (*Loxostege sticticalis* L.) are erroneously classed as true armyworms. These insects under certain conditions assume marching habits and cause a large amount of damage to miscellaneous crops.

CONTROL

Armyworms, unless they assume the marching habit, can be controlled by the use of poisoned bran bait as suggested for cutworms. When very abundant, however, these caterpillars sometimes travel in great hordes, migrating from field to field and destroying practically all vegetation as they move along. In such cases a heavy application of bait thrown across their path will usually check them, but sometimes it is necessary to resort to the trench method of control. In such cases a trench at least 10 inches deep is dug between the field to be protected and the advancing caterpillars. In the bottom of this trench post-holes, 1-2 feet deep, are dug at intervals of about 15 feet. These are for the purpose of trapping the insects as they wander along the bottom of the trench. Caterpillars caught in the post holes should be destroyed from time to time by pouring coal oil over them and igniting it. The side of the trench nearest the field to be protected should be straight, trimmed, if necessary, with a spade. In clay or muck soils this side of the trench should be roughened and pulverized by raking at intervals. Otherwise it bakes and when in that condition can be scaled by the armyworms.

WIREWORMS

Although primarily a pest of grasses, including grains, wireworms of various species commonly cause very severe injury to vegetables. In the spring they attack the seeds often before germination has taken place and such crops as corn are sometimes almost totally destroyed in this way. Later in the season the roots of many plants are injured by the feeding of these insects and during

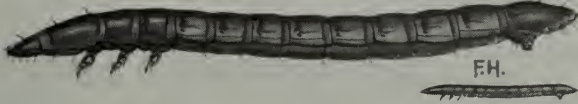


Fig. 13—Wireworms, enlarged and natural size (after Gibson and Twinn).

the late summer they bore into the fleshy roots of carrots, potatoes, onions and beets. Potato tubers are frequently attacked and rendered unfit for market by the tunnelling of these insects. Wireworms are practically omnivorous feeders although they seldom attack the roots of clover, buckwheat or flax.

The adults of wireworms are our common click beetles which vary in size and colour according to the species. They emerge from winter quarters early in the spring and lay their eggs in the soil of grasslands. Their life-history is very similar to white grubs as the larvæ live in the soil feeding upon the roots of plants for several seasons. When the larvæ reach their maximum size they pupate in the soil, the adults emerging the following spring. Wireworms are slender, elongated larvæ, about 1 inch in length when full grown and light, to darkish-brown in colour. They are found generally throughout Canada.

CONTROL

Eastern Canada.—In the control of wireworms it will be found that good methods of farming will assist very greatly. Healthy, rapidly growing plants are better able to withstand and outgrow the attack of these insects than ones which are unthrifty and undernourished. Induce quick, sturdy growth in the spring by having the land in good tilth and well fertilized. Plants growing in warm, well-drained land are less frequently injured than those in wet and cold soil. As wireworms are always more abundant in land which has been freshly broken, susceptible crops should not be planted in newly turned sod. Fall ploughing of land is recommended as it has a tendency to expose hibernating larvæ as well as pupæ to the action of the weather.

Rotation of crops is, perhaps, the best method of control, at any rate under field conditions. Clover, peas, buckwheat and flax are not susceptible to wireworm attack and should be used on infested land, until such time as the larvæ have matured. After two or three years it will be found quite safe to plant corn, potatoes and other, more frequently injured, plants. The use of grains, such as oats, wheat and barley, in the rotation is recommended.

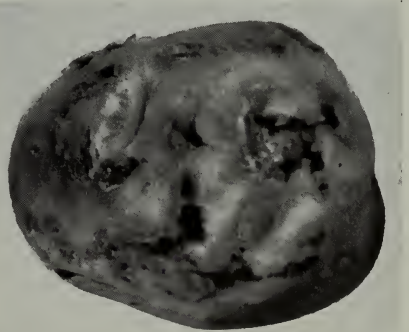


Fig. 14—Potato damaged by wireworms (after Gibson and Twinn).

Under garden conditions the use of baits, such as slices of raw potato, has given good results. These are placed in the soil in the spring before the crop has started at a depth of 2 or 3 inches and about 10 feet apart in all directions. Their position is marked by a white stick or painted wire and once a week the baits are examined, the wireworms removed and killed and the old potatoes, or new ones, replaced. This is done for 3 or 4 weeks by which time the number of wireworms will have been greatly reduced. Sprouting corn or balls of rice flour are also frequently used as baits.

Prairie Provinces.—In Western Canada the ground should be sprinkled with water to bring the wireworms to the surface before baiting. Use slices of potato placed 3 feet apart all ways and bury shallowly so that the top of the bait is exposed. Baiting is done before the crop is planted. When summer fallowed land is used for gardens, avoid infested fields. Practice crop rotation if wireworms are very abundant in the soil.

British Columbia.—In British Columbia rice shorts moistened and rolled into balls about the size of small oranges are used as baits. They are placed 10 feet apart, between growing plants in the field. Under field conditions where crop rotation is practised, the use of alfalfa is strongly recommended.

WHITE GRUBS

Some vegetables, such as potatoes, corn, etc., are frequently injured by a large white grub which lives in the soil and attacks the tubers and roots. It eats irregular holes into the potatoes and in some cases causes very serious damage. The roots of strawberries are also attacked and beans frequently suffer severely from the ravages of this insect. It is primarily a grass feeder but few cultivated plants are immune in years of heavy infestation.

The mature grub is about $1\frac{1}{2}$ inches in length. It is greyish-white for the most part, with brown head and legs. It is usually curved in a half circle when

at rest. It has a peculiar and unusual life-history in that it takes practically three years to complete its full development. The mature form is the large reddish June beetle which is frequently seen in the spring. The beetle feeds on the foliage of different shade trees and lays its eggs in ground which is covered with vegetation, such as grass. The grubs after they hatch live in the soil for the balance of that season, all through the next and for the first part of the third. They then pupate in the soil and the adults emerge the following spring. The grubs in feeding confine their attention wholly to the roots of plants, the maximum damage occurring the second year of their larval life. White grubs are present in every province of Canada.



Fig. 15—White grub feeding in potato (after Gibson).

CONTROL

In small gardens, where rotation of crops is not practical, digging out the grubs at the base of injured plants will give some relief. If pigs are allowed to run in the garden, either before the seeds are planted in the spring or after the crop has been removed, many of the white grubs will be located and eaten. As a method of prevention many of the adults, during flight years, may be captured by placing a lighted lantern in a shallow pan filled with a mixture of

water and coal oil and setting it out in the garden at night. Numerous beetles during flight years will be killed by spraying the trees on which they are feeding in spring with arsenate of lead, used at the rate of 2 pounds to 40 gallons of water.

Under field conditions crop rotation is the best control for these insects since it eliminates their favourite food plants. A frequently recommended rotation is as follows: plough infested ground thoroughly in the early autumn to expose the grubs before they go down into the soil; next year take off a crop of clover, re-plough in autumn and plant immediately to wheat. After this crop is harvested the soil should be free of white grubs and any crop may be planted with comparative safety.

GRASSHOPPERS

Although not primarily pests of vegetable crops, grasshoppers feeding on nearby pasture and grasslands occasionally migrate to gardens and attack the leaves of a variety of plants. Both young grasshoppers and adults are responsible for this damage. As a general rule only part of the leaf is eaten but in cases of severe infestation the plants will be practically stripped of their foliage. Most damage takes place in the late summer and autumn.

Several species of grasshoppers may be present in gardens in years of abundance, all of which have very similar life-histories. The eggs are laid in the soil during the autumn in small sacs known as egg-pods. Pastures, grasslands and roadsides are the situations usually chosen by the females for this purpose. In the spring the eggs hatch and the tiny, wingless hoppers feed on grasses and grains until fully grown when the winged adults appear. Migration then commences and the nearby gardens are invaded. Grasshoppers of one species or other are found all over Canada.

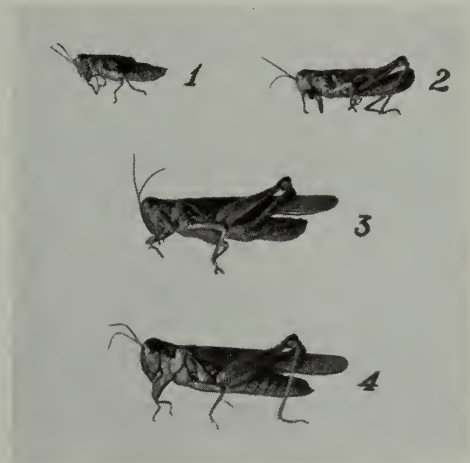


Fig. 16—Different stages of the lesser migratory grasshopper (after Gibson).

CONTROL

Eastern Canada.—When grasshoppers are present in the garden in injurious numbers they may be controlled by the use of a poisoned bran bait which is scattered on the surface of the ground on a warm day. This bait is made up according to the following formula:—

Bran.....	25 pounds
Paris green (or white arsenic).....	1 pound
Salt.....	1 pound
Water (about).....	2½ gallons

Where sawdust is available, use half bran and half sawdust in the mixture. The dry ingredients should be thoroughly mixed in a large tub or on a cement floor. After the salt is dissolved in the water the liquid is poured over the bran and poison and the materials stirred until the bait is of the consistency of wet sawdust. It should not be sloppy but should crumble and fall through the fingers readily. The bait is spread thinly over the surface of the ground between 10 and 11 a.m., when the temperature ranges between 70° F. and 85° F. It is quite useless to put out the bait on a cold or even cool day and making the

application when the temperature is very high is not recommended. The material should be applied when the grasshoppers are feeding and distributed at the rate of about 10-15 pounds per acre. One application is usually sufficient but a second may be necessary a few days after the first.

As this material is extremely poisonous great care must be exercised so that live stock or children will not have access to it either in receptacles or in the field.

The addition of fruit juices, molasses and amyl acetate to the bait, as recommended formerly, has been discontinued in the East as it has been found that the practice increases the cost of the treatment without changing the efficiency of the remedy to any extent.

Prairie Provinces.—Control the same as in Eastern Canada.

British Columbia.—A slightly different bait is used in this province which is made up of the following materials:—

Bran.....	50 pounds
Liquid sodium arsenite.....	1½ pints
Salt.....	4 pounds
Amyl acetate.....	2 ounces (fluid)
Molasses.....	2 quarts
Water.....	5 gallons

This bait is spread in the same manner and under similar conditions as described above.

THE BERTHA ARMYWORM, *Barathra configurata* Walk.

Although primarily a pest of field crops, such as clover, alfalfa and flax, the bertha armyworm frequently causes serious injury in gardens to cabbage, corn, peas, beans, beets and other vegetables. The caterpillar feeds on the foliage and in the case of cabbage eats deep holes into the forming, or fully formed heads. In some seasons vegetable crops suffer considerably from the attack of this insect.

The caterpillar when full grown is about as thick as a lead pencil and 1½ inches in length. In the last stage it is a black conspicuously striped form while in the early stages it is greenish and marked with whitish lines. The winter is passed as a pupa in the soil, the moths emerging in June to lay their numerous eggs in flat masses upon vegetation. There is only one generation each year. This insect is essentially a pest of Western Canada.

CONTROL

Thorough dusting of infested plants with a mixture of arsenate of lime and hydrated lime, used in the proportion of 1 part of the poison to 8 parts of the lime will hold this insect in check. The plants should be completely and evenly covered with the dust. In the case of cabbage it is recommended that they be treated at intervals of a week to 10 days, beginning soon after they are set out and continuing until the heads are $\frac{2}{3}$ formed. This should be done as a matter of precaution. The same dust is equally effective against other caterpillars attacking cabbages.

The use of poisoned baits as recommended for cutworms on page 17 will give good control when used against this insect. The bait should be scattered on the ground beneath the plants in the evening of a warm day.

GARDEN SLUGS

Slugs are always most abundant in wet seasons or in moist situations. They are nocturnal in habit, hiding during the day beneath the soil or in damp refuse and emerging at dusk to attack their host plants. They feed chiefly on the undersurfaces of the leaves, rasping off the epidermis and causing the tissues to



Fig. 17—The garden slug (after Gibson and Ross).

turn brown and die. Holes appear in the leaves and when the infestation is heavy severe injury to crops results. Full grown slugs are about $1\frac{1}{2}$ inches long. They are usually grayish to brownish in colour with certain faintly defined markings on the body, this varying with the species to some extent. The winter

is passed chiefly in the egg stage, in the soil, although adults have been known to hibernate successfully. The eggs are round, translucent and generally laid in small clusters just below the surface of the ground. They hatch in early June, the young slugs according to our observations feeding by preference on the lower parts of dandelion leaves. Cabbages, cauliflowers, beans and lettuce seem the favourite food although slugs will feed on a wide range of vegetation. Slugs are found in all provinces of the Dominion.

CONTROL

Eastern Canada.—Dust infested plants and slugs with hydrated lime in the evening after the sun has gone down and feeding has commenced. Care should be taken to cover the upper and lower surfaces of the leaves and the soil immediately surrounding the plants. Hydrated lime is effective only when in the form of a light, dry powder. It becomes hard when subjected to moisture and in that condition is non-injurious. For this reason a few light applications of lime at intervals of three or four days are much more effective than one heavy dose.

Another method of control that is frequently recommended is to spray the infested plants thoroughly with Bordeaux mixture. This material is repellent to slugs and if the foliage is completely covered many of them will confine their attention to weeds growing in the field. The preparation of Bordeaux mixture is discussed on page 8.

Prairie Provinces.—On the prairies, slugs are controlled by the use of the regular cutworm bait, the formula for which is given on page 17. Spread this bait around the base of the plants in the late evening of a warm day. Repeat applications as needed.

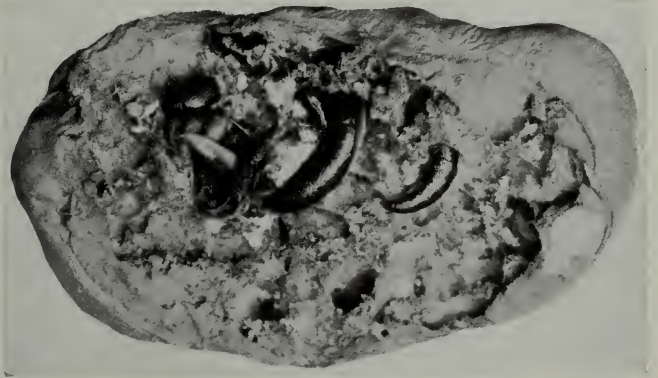


Fig. 18—Garden slugs feeding on potato (after Gibson and Twinn).

British Columbia.—Dust infested crop with dehydrated copper sulphate and hydrated lime in proportion of 1 part of the former to 10 parts of the latter. This dust must be applied after dark, using it at the rate of 50 pounds per acre or 10 pounds per 2,500 lineal feet of row. The use of salt and lime (1-10) dusted over soil beneath the plants and along the borders of the field is also recommended.

THE TARNISHED PLANT BUG, *Lygus pratensis* L.

Fig. 19—Potato foliage injured by tarnished plant bug (original, from photo by R. H. Painter).

The tarnished plant bug feeds upon a wide range of field and garden crops as well as weeds and shrubs. It attacks the buds, blossoms, leaves and new growth, sucking out the plant juices by means of its sharp pointed beak. Due to its work plants become stunted and frequently the terminal shoots are killed. Leaves which have been attacked show feeding scars and usually become curled and dwarfed. Buds and blooms of flowering plants either do not unfold or become distorted and are ruined for market purposes. Practically all vegetable crops are attacked. Among the flowering plants—dahlias, asters, helichrysum and gladioli are most severely injured. The insect is practically omnivorous.

The tarnished plant bug hibernates in the adult stage, hidden away under rubbish or concealed beneath fallen leaves in woodlots. The adult is about $\frac{1}{4}$ of an inch long, brownish in colour and very active, particularly on

warm days. It emerges very early in the spring and lays its eggs in the tissues of a wide range of cultivated and wild plants. The nymphs are yellowish-green in colour and, although unable to fly, can run very rapidly. They injure the plants in a similar manner to the adults. The tarnished plant bug is distributed all over Canada.

CONTROL

There is no satisfactory control known for this insect at the present time. The cleaning up of rubbish in and around the garden is recommended, as this removes much of the material under which the insect is in the habit of hibernating. However, in the case of such an active bug this practice has little value for it quickly flies in from outside breeding grounds. Spraying or dusting with contact insecticides gives little relief. Work in connection with the control of this insect is being carried on at the present time and it is hoped that an effective remedy will be found in the near future.



Fig. 20—The tarnished plant bug, enlarged and natural size (original).

THE FOUR-LINED PLANT BUG, *Poecilocapsus lineatus* Fab.

Leaves of certain vegetable and flowering plants are occasionally attacked by nymphs and adults of the four-lined plant bug. The injury is very typical. The insect has sucking mouth parts and feeds by inserting its beak into the leaves and tender growth. Affected leaves present a spotted appearance and the terminal growth of injured shoots is frequently stunted or killed. Mint is a favourite host, although currants, gooseberries, potatoes, dahlias and a large range of other plants are also attacked.



Fig. 21—Four-lined plant bug injury to leaves of weigelia (after Gibson).

The winter is passed in the egg stage. The eggs are inserted in the young wood of currant bushes chiefly. These usually protrude slightly and for that reason are easily detected. They hatch in May and the nymphs which are bright red in colour become fully grown in about 6 weeks. The adults are striking looking insects. They are about $\frac{1}{3}$ of an inch long, greenish-yellow in colour and with four black stripes extending down the thorax and outer wings. There is only one generation of this insect annually. Commercial damage occurs only in Eastern Canada.

CONTROL

The nymphs or wingless forms may be partially controlled by spraying or dusting the infested plants with nicotine sulphate. As a spray use the material at the rate of $\frac{1}{2}$ a pint to 40 gallons of water to which has been added 2 pounds of laundry soap. A $2\frac{1}{2}$ -3 per cent nicotine dust, as described on page 9, should also be effective. Spray or dust the plants thoroughly, forcing the insecticide

into the curled leaves where the insects are feeding. Kerosene emulsion, (page 7), diluted 1 to 9 with water, is also recommended. Thorough and frequent applications of these remedies are necessary to bring about control. Due to their great activity the winged forms are not affected by these remedies as they fly away before the materials come into contact with them.



Fig. 22—The four-lined plant bug, enlarged and natural size (original).

THE EUROPEAN EARWIG, *Forficula auricularia* L.

In areas where it is abundant, the European earwig causes serious damage to miscellaneous vegetable crops by feeding on the foliage. It is especially attracted to beans, potatoes, peas, dahlias, roses, carnations and asters but in the case of heavy infestations practically all growing plants are attacked. Feeding occurs almost altogether at night, the earwig hiding in the soil during the daytime. The mature earwig is about $\frac{4}{5}$ of an inch in length, of a dark reddish-brown colour. The legs, feelers and small wing-covers are yellowish-brown. At the end of the body is a pair of forceps or pincer-like structure.

The winter is passed in the adult stage in the soil. Eggs are laid in the ground in spring and upon hatching, the tiny, white to grayish earwigs are supposed to feed at first on the roots of miscellaneous plants. As they increase in size they come to the surface and attack the aerial portions of plants. After reaching maturity the adults feed for a considerable time and, following mating, enter the ground for hibernation. In Canada the earwig is found only in the province of British Columbia.

CONTROL

Earwigs are controlled by the use of a poisoned bait which is scattered over infested ground during warm evenings of late May or early June. In gardens, the material is distributed among the plants in a manner similar to the poisoned bait for cutworms. The bait recommended for use against earwigs is made up of the following ingredients:—

Sodium fluoride.....	12 ounces
Molasses.....	2 quarts
Wheat bran.....	12 pounds
Water.....	6 quarts

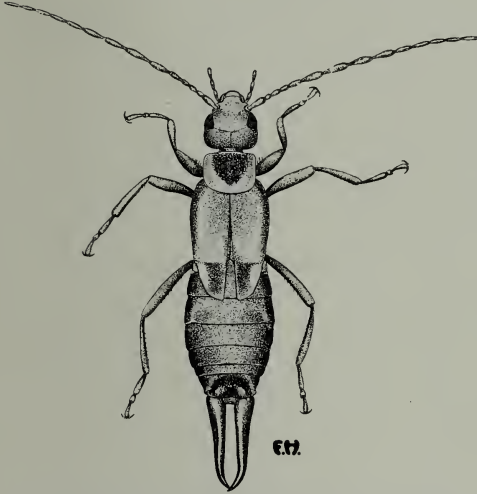


Fig. 23—The European earwig, enlarged four times (after Gibson).

Dissolve the sodium fluoride and molasses in the water and then add the mixture to the bran. This should be stirred thoroughly until the bait is of the consistency of wet sawdust. If more liquid is required water should be added. This bait is applied whenever the insects become numerous. To be effective in a district where household properties adjoin, control measures should be applied concurrently by all residents. In a city, community baiting by municipal authorities is most economical and successful.

In small gardens if crumpled newspapers are scattered about at night many earwigs will hide therein and can be gathered in the morning and burned.

The following earwig bait, used at Victoria, B.C., has given good results:—

Bran.....	12 pounds
Molasses.....	1 quart
Beef scrap (or meat meal).....	2½ pounds
Sodium fluoride.....	12 ounces
Water.....	6 quarts

Soak the beef scrap for 3 hours or more before using. Dissolve the sodium fluoride in the water, add the molasses and mix with the bran to make a crumbly mash. Scatter in the evenings in June and July. Thirty pounds is sufficient for an ordinary city lot. Watering the garden afterwards should be delayed for 2 or 3 days.

As both these baits are poisonous, every precaution should be taken in their use to see that they are kept away from children and domestic animals.

SOD WEBWORMS, *Crambus* spp.

In the spring young corn plants when about 4 to 6 inches in height are sometimes cut off at the ground level by small caterpillars which live in little silken cases constructed just below the soil surface. These are sod webworms of which there are a number of different species in Canada. The damage caused by these insects closely resembles the work of cutworms. Corn and tobacco plants are frequently injured by these caterpillars as are also a variety of grasses.

The caterpillars are usually thick-bodied and when full grown are about $\frac{3}{4}$ of an inch in length. They pass the winter as partially grown larvæ in silk-lined nests in grass and sod land. With the return of warm weather feeding commences and it is at this season that most damage is done. When full grown the caterpillars pupate in the soil and the moths emerge later to lay their eggs around the lower parts of grass stems. Most species have only a single generation in Canada.



Fig. 24—(1) and (2), Tobacco seedlings injured by sod webworm; (3) stages of sod webworm—larva, pupa, larval case and adult (original, from photos by G. M. Stirrett).

CONTROL

By ploughing land early in the autumn before the females have had a chance to deposit their eggs at the base of any grass or weeds they will be forced to migrate to other more suitable situations to oviposit. If this is not possible the fields should be ploughed late and harrowed to expose any caterpillars hidden away in their silk-lined cells. Such cultivation breaks up the hibernation nests and exposes the larvæ to the action of the weather. If fields of corn or tobacco are so severely damaged in the spring that replanting is necessary, the seed or new plants should be placed between the old rows, since the latter will serve as food and will protect the new plants until they become too large to be injured by the sod webworms.

THE BURDOCK BORER, *Papaipema cataphracta* Grt.
and

THE STALK BORER, *Papaipema nebris nitela* Guen.

Stems of flowering and vegetable plants are frequently attacked by one or other of these borers. The insects gain access to the stem by eating a small hole through the side. Once within, they feed on the internal tissues and usually are responsible for bringing about wilting and subsequent death of the plant attacked. They have the habit of migrating from host to host which results in more serious injury than if only one plant was attacked. The burdock borer and the stalk borer feed on a very wide range of cultivated and wild plants.



Fig. 25—The burdock borer and its work (after Gibson).

Both caterpillars are pale brown in colour with a white stripe down the back and one down each side. In the case of the burdock borer the lateral stripes are continuous, while in the stalk borer the stripes along the sides are broken. These larvæ are about $1\frac{1}{2}$ inches long when full grown.

The winter is passed in the egg stage, the eggs being laid on fleshy-stemmed weeds and on the stems of cultivated food plants. They hatch in June, the young caterpillars entering the first suitable plant encountered. In some years these insects are abundant in Eastern Canada.

CONTROL

The work of these borers usually becomes noticeable by the middle of June, the tops of infested plants wilting and turning brown. As both the burdock borer and the stalk borer have the habit of migrating from plant to plant while feeding, injured stalks should be cut off and destroyed by burning as soon as they are seen. In this way much damage will be averted. In the late autumn clean up and burn all refuse in the gardens since many eggs will be destroyed in this way. For a similar reason nearby grasslands and weedy patches should be burned over in the spring before any hatching takes place.

THE GARDEN SPRINGTAIL, *Sminthurus hortensis* Fitch.

The stems and leaves of seedling plants are sometimes attacked in the spring by the garden springtail. This minute insect sometimes appears in great numbers and eats small circular holes in the leaves. Frequently the stems are so severely injured as to be partially or entirely cut off. Such plants as cabbage, radish, turnip, onion, cucumber, squash, etc., are attacked.

The garden springtail is about $\frac{1}{20}$ of an inch in length, dark blue in colour and able to jump very quickly for comparatively long distances. On account of its extremely small size and its ability to spring off the plants when disturbed it frequently escapes the notice of growers. It is reported as having caused important losses in Eastern Canada.

CONTROL

It is most important that control measures for these insects be applied upon the first appearance of injury, since they are very difficult to check once they become numerous. Dr. W. H. Brittain, who has carried on control studies with the garden springtail in Nova Scotia, recommends treating the young seedlings with a 2 per cent nicotine dust. The material must be liberally and thoroughly applied. Air slaked lime, sulphur or tobacco dust when applied to the infested plants help considerably but are not so effective as nicotine dust. Directions for the preparation of the latter will be found on page 9.

MILLIPEDES

Millipedes occasionally injure plants in gardens by feeding on the tender roots, thus weakening or killing their hosts. They sometimes attack sprouting seed, such as corn, and may damage young seedlings by eating into the tender stems beneath the soil surface. They have the habit, also, of boring into potato tubers and root crops and frequently eat holes into tomatoes, cucumbers, squash, etc., where they touch the ground. They are dark brown to almost black in colour, depending on the species, and when full grown about 1 inch in length. Millipedes are elongate, cylindrical creatures of many distinct segments, each of which, with the exception of the first 4, bears 2 pairs of legs.



Fig. 26 -Common millipede (after Gibson and Ross).

CONTROL

In small gardens millipedes may be reduced in numbers by the use of baits and traps. Slices of potato dipped in a strong solution of Paris green and water or dusted with Paris green will attract many of these little animals. The pieces of potato are placed in the soil near injured plants. The millipedes while feeding will swallow some of the poison and be killed. Lumps of dough sweetened with molasses attract a certain percentage of the millipedes and many of them will congregate beneath boards or shingles placed on top of the ground. They can then be collected from these traps and killed by dropping them into a vessel containing coal oil and water. Under field conditions no control is known. Fortunately, however, they are very seldom troublesome except in small gardens.

INSECTS ATTACKING ASPARAGUS

THE ASPARAGUS BEETLE, *Crioceris asparagi* L.

In the spring the young and tender asparagus shoots are frequently injured by the feeding of the asparagus beetle which disfigures and renders them unfit for market. When the larva appears it joins the adult in this work of destruction, feeding not only on the new shoots but, later in the season, attacking also the foliage and even the stems of the plant. The damage continues all summer. This greatly weakens the plants and as a result the amount of food stored up in the roots for next season's growth is much reduced. As far as can be learned asparagus is the only species attacked.

The beetle is about $\frac{1}{4}$ of an inch long with the ground colour bluish-black. It has a red thorax and yellow markings on the wing covers. The insect passes the winter in the adult stage, hidden away under rubbish or in old stumps or under leaves. About the time the asparagus shoots appear, the beetle emerges and commences feeding. Egg-laying quickly follows and the larvæ, upon hatching, immediately attack the tender plants. The larva, or immature form, is about $\frac{1}{3}$ of an inch long when fully grown. It is dull gray in colour with black head and legs. In this species the eggs are laid on their ends in rows along the stems and leaves. In Canada the asparagus beetle is a pest of importance only in the provinces of Quebec and Ontario.

CONTROL

The most serious injury by these insects takes place in the spring at cutting time, consequently the beds will have to be carefully watched at that season and at the first sign of damage the following control measures put into force.

(1) Cut over beds frequently, at least once every 2 or 3 days, so that the beetles will not have time to injure seriously the tender shoots between cuttings.

(2) Leave short sections of row uncut every here and there throughout the bed. These will act as a trap and should be kept sprayed with arsenate of lead, 2 pounds to 40 gallons of water to which has been added 2 pounds of laundry soap.

(3) Plantings which have not reached the cutting age should be kept sprayed throughout the season with arsenate of lead and soap.

(4) As soon as the cutting season is over spray all plants with the above mentioned poison, repeating the application when necessary. A potato sprayer can be used for this purpose, lifting the boom sufficiently to allow the plants to pass underneath.

(5) Late in the fall burn all rubbish in and around the beds to kill the hibernating beetles.



Fig. 27—(1) The asparagus beetle;
(2) eggs of asparagus beetle
(original, from photo by W. Robinson).

THE SPOTTED ASPARAGUS BEETLE, *Crioceris duodecimpunctata* L.

The injury brought about by the spotted asparagus beetle is very similar to that already described for the asparagus beetle. The beetle injures the tender shoots in the spring and as the season advances attacks the foliage and branches. The larva in the case of this species, however, injures the berries only and is never found feeding on other parts of the plant. For this reason very little damage is done by the immature forms. Asparagus is the only food plant.

The adult is reddish in colour with 12 black spots on the wing covers and is similar in size and shape to the other asparagus beetle. The beetle hibernates



Fig. 28—The spotted asparagus beetle, enlarged and natural size (original).

under rubbish or in fence posts or under the bark of trees, in fact almost anywhere where it is afforded adequate protection. The tender shoots are attacked by the emerging beetles almost as soon as they appear above ground. Egg-laying is delayed, however, until the berries commence to form, the eggs in the case of this species being dark green and laid on their sides along the branches. Upon hatching the larvæ attack the berries, feeding inside for the most part and migrating from one to the next as the source of food becomes exhausted. They vary in colour from yellowish-white to orange and are approximately $\frac{1}{3}$ of an inch long when full grown. This insect is only known to occur in the provinces of Quebec and Ontario.

CONTROL

The control for this insect is similar to that already described for the asparagus beetle.

INSECTS ATTACKING BEANS

THE BEAN WEEVIL, *Mylabris obtectus* Say

Beans in warm storage are sometimes attacked by the bean weevil. This small insect lives within the seed in a small chamber which it forms while feeding. Each insect makes only one such cell but a seed, if heavily infested, may contain a great number of these chambers and in extreme cases the bean may be totally destroyed. In Canada, growing beans are seldom injured, the weevil confining its attack chiefly to beans in storage.

The adult bean weevil is a beetle about $\frac{1}{8}$ of an inch in length and yellowish-brown in colour. It lays its eggs on the outside of the seed. The larva is at first provided with legs by means of which it is enabled to move around and select a suitable spot where the bean may be entered. It bores through the outer coat and once inside commences to eat out a small cell where it spends the rest of its life. The larva when full grown is about $\frac{1}{8}$ of an inch in length and is a white, legless grub. Pupation takes place in the chamber, the adult emerging when mature to lay its eggs on other beans. There are many generations a year in Canada, if the temperature is suitable. The insect is of economic importance chiefly in Quebec and Ontario.

CONTROL

The bean weevil is unable to survive when exposed to winter temperatures in Canada. Accordingly beans should be stored in unheated granaries or seed houses where the temperature inside the building will closely approximate that outside.

Infested seed should never be planted without previous treatment. If beans contain weevils they should be fumigated with carbon bisulphide. The seed is placed in a tight building or, if the



Fig. 29—The bean weevil, enlarged and natural size (after Gibson and Twinn).



Fig. 30—Beans injured by the bean weevil (after Gibson and Twinn).

Care must be exercised in the use of carbon bisulphide as the fumes are poisonous to humans and quickly ignite and explode when brought in contact with fire in any form. This fumigant can be purchased at most seed houses or wholesale drug stores.

quantity to be treated is small, in a well made barrel or other container. The carbon bisulphide is placed in shallow dishes on top of the beans and the building or barrel tightly closed, the cracks around the opening being sealed up with paper. The fumigant should be used at the rate of 8-10 pounds per 1,000 cubic feet or about $\frac{1}{4}$ of a pint per 40 gallon barrel. Fumigation should continue for 48 hours and the temperature for best results should be at least 70° F. If the exposure is shortened or if the temperature goes below this point not all the beetles will be killed. After the full time recommended for fumigation has elapsed the chamber should be opened and allowed to air thoroughly before being entered.

THE SEED-CORN MAGGOT, *Hylemyia ciliatella* Rond.

Such seeds as beans and corn are frequently attacked after planting by the seed corn maggot. This insect either tunnels into the seed before germination takes place or else attacks the stems of the young plants soon after they have appeared above ground. Injury is always more serious in a cold, backward spring or when the seed has been planted in damp, cold land. The insect feeds on a wide range of seeds, but beans, corn and potatoes are most generally attacked in Eastern Canada.

The maggot when fully grown is $\frac{1}{4}$ of an inch long and whitish in colour. The insect winters as a pupa in the soil near where the maggots were feeding the previous autumn. About the middle of May the greenish-gray fly emerges and

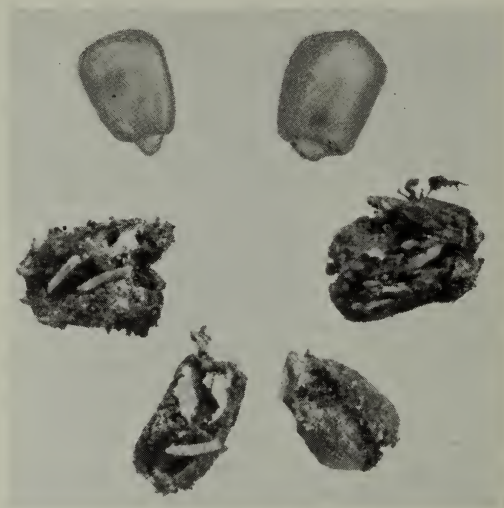


Fig. 31—Corn seed injured by seed corn maggot (original).

lays its eggs in the soil near some form of decaying vegetable matter, such as turned under manure or humus. The eggs hatch in a few days and the tiny maggots work their way into any suitable food which may be nearby, as for instance seeds in process of germination. The insect occurs in all provinces of Canada.

CONTROL

There is no definite and specific control for this insect, although there are several steps which the grower may take by way of prevention which will help in reducing the amount of injury.

(1) Plant susceptible crops on well-drained land and in soil that is naturally warm.

(2) If manure is to be used as a fertilizer it should be well rotted rather than green and should be spread and ploughed down in the autumn.

(3) Work up the seed bed thoroughly to insure quick germination of seed and vigorous growth.

(4) Sow seed as shallow as possible, since the upper soil is usually warmer than that at a greater depth.

(5) If the spring is wet and cold, delay seeding until warmer weather prevails.

(6) If the first crop is destroyed by this insect it is usually safe to replant as the majority of maggots will have reached their maximum growth and have ceased feeding by that time.

NUTTALL'S BLISTER BEETLE, *Lytta nuttalli* Say

This large blister beetle, measuring almost 1 inch in length, is metallic green or purplish in colour. It is a ravenous feeder causing serious injury to such plants as caragana, wild vetches and licorice. Under garden



Fig. 32—Nuttall's blister beetle; hair line indicates natural size (after Gibson).

conditions beans, particularly broad beans, frequently suffer from the attack of these insects. The life-history and control of Nuttall's blister beetle is similar to that of other blister beetles described on page 68.

THE MEXICAN BEAN BEETLE, *Epilachna corrupta* Muls.

In certain sections of the United States, beans are badly damaged by the Mexican bean beetle. The insect attacks chiefly the undersurfaces of the leaves, eating off the tissue until only a skeleton of midribs and veins remain. Frequently entire crops are destroyed and enormous losses suffered. Different varieties of beans are the chief food plants, but in severe infestations alfalfa, clovers, vetch and certain grasses and weeds are attacked.

The adult belongs to the "lady-bird" beetle family and is $\frac{1}{4}$ to $\frac{1}{3}$ of an inch in length, convex and rounded in outline and coloured from yellow to coppery brown. It has 16 black spots on the back. Feeding is done by both adults and larvæ. The adult overwinters under dry leaves and other rubbish on the ground, usually near bean fields. The earliest beetles are found in the field about the time the first beans appear and other individuals continue to emerge over a period of about two months. The yellowish eggs are laid in groups on the under surface of the leaves, about 40-50 in a cluster. Hatching takes place in about 10 days when the young insects commence feeding on the lower surface of the leaves. The larvæ are about $\frac{1}{3}$ of an inch in length, when full grown, yellow, and covered with rows of long, branching spines. The Mexican bean beetle has been found only in sections of Southern Ontario where as yet it has caused little damage, but gardeners should be on the watch for it.

CONTROL

Good cultural practice assists greatly in the control of this insect. Induce healthy, vigorous growth in the spring by careful preparation of the seed bed and by the liberal application of fertilizers. Strong, thrifty plants are much

better able to withstand an attack of the beetles than less vigorous ones. In the summer as soon as the crop has been removed the plants should be ploughed under, since this has the effect of burying and destroying many of the immature forms. Cleaning up of old plant refuse in and around the bean fields in the autumn is advised, as the beetles are in the habit of passing the winter under such piles of debris.

When the beetles become numerous spray or dust the infested plants. Bean foliage is most susceptible to arsenicals and for this reason great care must



Fig. 33—Bean plant showing injury to foliage by larvae and adults of the Mexican bean beetle (original, from photo by G. M. Stirrett).

be taken in their selection and application. Experiments carried on in the United States have shown that magnesium arsenate as a spray and calcium arsenate as a dust are the safest and most effective poisons for use against this insect. Magnesium arsenate should be used at the rate of 1 pound to 40 gallons of water, while for dusting, calcium arsenate is diluted with 7 parts of hydrated lime.

In spraying or dusting pay special attention to the undersurfaces of the leaves, where the insects feed. Apply the spray at the rate of 100-125 gallons per acre at each treatment, depending on the size of the plants. If dusting is preferred at least 15-20 pounds are necessary to cover an acre thoroughly.

Treatments should be given at intervals of from 1 week to 10 days, the number varying with the infestation, although 4 or 5 are usually necessary where the insects are abundant.

THE BANDED FLEA BEETLE, *Systema taeniata* Say

The banded flea beetle in certain seasons attacks beans and other vegetable crops. It feeds on the foliage, eating small circular holes through the undersides of the leaf. In cases of severe damage these holes coalesce and the leaves may turn brown and die. Injury to the roots of onions and to sprouting corn by the larva has been reported from the United States. Beside beans such crops as peas, potatoes, egg-plants, carrots, parsnips, cabbages, radishes, cucumbers, etc., are often injured. The beetle also feeds on a variety of flowering plants and weeds.

It is not definitely known just how the insect hibernates but in the spring the adult appears and attacks its favourite plants. The beetle is $\frac{1}{8}$ of an inch in length, pale-brown with a cream-coloured band on each wing cover. The antennae and legs are reddish or yellowish-brown and the head is red. The eggs are laid in the soil and the larvæ feed on the roots of plants until fully grown. It is thought that they pass the winter in this stage and pupate the following spring. There is only one generation in Canada.

CONTROL

Like most other flea beetles, this species can be controlled by spraying the infested plants with Bordeaux mixture as described on page 15.

THE BEAN APHID, *Aphis rumicis* L.

During the summer months the bean aphid feeds on the foliage of such vegetables as beans, peas, beets, celery, asparagus, onions, rhubarb, etc. The insect, which is black in colour, attacks the leaves and tender stems, sucking out the juices of the plant and greatly reducing its vitality. Curling and yellowing of the foliage results and yields are much decreased.

In the late summer the bean aphid lays its black eggs on such shrubs as snowball, syringa, deutzia, etc. The winter is passed here and in the spring the first generation develops on the buds and foliage of the winter host plants. In the third generation winged adults appear and migrate to the summer host plants such as garden vegetables, noted above, where feeding continues until autumn. The insects then return to snowball, syringa, etc. Mating takes place and the eggs are again laid on the bark of these bushes. There are 8 or 9 generations during the feeding period. The bean aphid is reported as occurring in the Maritime Provinces, Quebec, Ontario and British Columbia.

CONTROL

Thorough dusting or spraying of the infested plants as outlined for the control of aphids in general, given on page 14, will control bean aphids. Make the first application as soon as the insects appear, paying special attention to the undersides of the leaves.

INSECTS ATTACKING BEETS AND SPINACH

THE BEET WEBWORM, *Loxostege sticticalis* L.

Garden crops are sometimes very seriously damaged by the beet webworm. When abundant and migrating this caterpillar will attack practically all varieties of vegetables, eating the leaves and completely destroying the plants. Weeds, particularly Russian thistle, are its favorite food plants and these are eaten in preference to anything else. Low growing willows, aspens and cherries are also attacked to some extent.

The full grown caterpillar measures about 1 inch in length and is rather slender. Its general colour is green or yellow with very distinct black markings

arranged in lines and circles. The larva passes the winter in the soil enclosed in a long silken tube or cocoon in a vertical position just below the surface. In the spring, pupation takes place inside the cocoon, the small, light brown moth emerging about the middle of May to lay its eggs on such favorite host plants as pigweed, lamb's quarters and Russian thistle. There are two generations of this insect. The beet webworm is essentially a prairie pest.

CONTROL

When a garden is threatened with an invasion of these insects, trenching and poisoning should be resorted to. Plough a deep furrow around the garden, paying particular attention to the side from which the caterpillars are entering. Be careful to turn the land away from the garden and toward the advancing insects. Since beet webworms spin a web as they crawl along they would soon be able to bridge this furrow unless killed by a poison. A bait made of chopped up weeds, such as lamb's quarters and etc., sprinkled with Paris green, is very effective for this purpose. Cut the plants up fairly fine and sprinkle thoroughly



Fig. 34—The beet webworm, natural size (after Gibson).

with water. Dust 1 pound of Paris green over about 50 pounds of the bait and by means of a fork turn it over several times until the poison is evenly distributed over the plants. This bait is then spread along the bottom of the furrow. When it becomes too dry to be attractive it should be replenished.

If the caterpillars have gained entrance to a garden or field they can be checked by spraying the plants with a mixture composed of Paris green 3 pounds, hydrated lime 3 pounds and water 100 gallons. When migration of the beet webworms into a field is noticed sufficiently early, it should be necessary to spray only a strip a few yards wide on the menaced side of the field to prevent their entry. Dusting infested plants with Paris green or arsenate of lime, using 1 part of either poison to 10 parts of hydrated lime should prove equally effective.

THE SUGAR BEET ROOT APHID, *Pemphigus betae* Doane

The sugar beet root aphid is frequently found feeding on the roots of such plants as sugar beets, beets, mangels and some weeds, as lamb's quarters, yarrow, dock, golden rod and miscellaneous grasses. As a result of its attack both the size and quality of the beets are reduced.

The winter is passed in the egg stage on the bark of poplar trees and in part as wingless females on the roots of herbaceous plants. The insects are yellow in colour and have a mass of cotton-like, waxy threads attached to the body. A migration of winged aphids from poplar to beets takes place in July and a return migration to poplars in the autumn. The insect is confined chiefly to Western Canada.

CONTROL

Have land free from all weeds, such as lamb's quarters, dock, sorrell, bindweed, knotweed and waterpepper. Practice crop rotation, being careful not to have beets or mangels follow buckwheat. Never plant susceptible crops in the vicinity of cottonwood trees, since the insects migrate from these trees in the early summer. In irrigated land frequent irrigation to prevent cracking of the soil is effective.

THE SPINACH LEAF MINER, *Pegomyia hyoscyami* Panz.

Severe injury to the leaves of spinach and beets is frequently caused by the work of the spinach leaf miner. This tiny insect has the habit of tunnelling within the leaves of these plants, causing brown serpentine markings and blotches to appear. The margins of the leaves are most frequently disfigured and in severe infestations a percentage of the leaves may actually be killed. The damage is more noticeable in the case of spinach than beets since the leaves form the edible part of the plant in the former. In addition to spinach, chard and beets, mangels, pigweed and lamb's quarters are also attacked.

The maggot is creamy-white in colour and when newly hatched is extremely small. The insect over-winters in the pupal stage a few inches below the surface



Fig. 35—Beet leaves injured by the spinach leaf miner (after Gibson and Twinn).

of the ground. Toward the latter part of May, the adult, which is a small grayish fly, emerges and a few days later begins to lay its eggs on the undersides of the leaves. The eggs are white and laid on their sides in small clusters of from 2 to 5. Hatching takes place in a few days, the larvæ at once boring into the leaves where feeding commences. The maggots often move to another spot on the leaf and migration from leaf to leaf frequently occurs. The insect is found generally throughout Canada.

CONTROL

The spinach leaf miner is very difficult to control in view of the fact that it spends practically all of its life in mines within the leaf. Also, it is unsafe to spray spinach leaves with an arsenical for fear of poisoning the consumer. To kill the flies Prof. L. Caesar advocates spraying beets and mangels with a solution composed of $1\frac{1}{2}$ pounds of arsenate of lead, $\frac{1}{2}$ a gallon of molasses and 40 gallons of water, the first application being made when the first eggs are seen on the undersides of the leaves and a second application 4 or 5 days later. The material should be applied about 4 p.m. on a bright, warm, calm day. The spraying would only be effective in dry weather.

The destruction of wild host plants, such as pigweed, lamb's quarters, etc., as soon as the mines become numerous, will assist in reducing the number of the insect.

THE SPINACH CARRION BEETLE, *Silpha bituberosa* Lec.

The leaves of beets and spinach are frequently injured by the adults and larvæ of this species. Feeding usually occurs at night as the insects hide during the day in soil at the base of their host plants. The beetles and larvæ feed on the edge of the leaves and, when disturbed, drop to the ground. In addition to the above mentioned plants, swede turnips, mangels, squash, pumpkins, alfalfa, wheat, lamb's quarters, nightshade and other cultivated and wild plants are attacked.

The adult is a black beetle about $\frac{1}{2}$ an inch long and having 3 longitudinal ridges on each wing cover. It hibernates in the soil and emerges in the spring to lay its eggs in moist ground, some being deposited as deep as 2 inches. The larvæ are black with white connecting membrane and when full grown are slightly over $\frac{1}{2}$ an inch in length. This insect is a pest of commercial importance only in Western Canada.

CONTROL

Dusting infested plants with calcium arsenate, diluted in 10 parts of hydrated lime or flour will control these insects. The use of grasshopper bait as described on page 21 is also effective and is used with good results on the prairies.

THE GREEN PEACH APHID, *Myzus persicae* Sulz.

This insect is known also as the spinach aphid, since it very frequently causes serious injury to that crop by feeding on the foliage and tender growth. Other vegetables sometimes attacked are celery, lettuce, beet, tomato, potato, cabbage, cucumber, etc. This aphid also feeds on a number of weeds and in the spring injures peach, plum, apricot and cherry buds.

It passes the winter in the egg stage, the black eggs being laid on the twigs of peach, plum or cherry trees. Hatching takes place in the spring when the young, yellowish-green nymphs begin feeding on the opening buds. At first the aphids are all wingless, but winged forms soon appear which migrate to spinach and other vegetables and weeds. Feeding continues here during the summer but with the approach of cool weather the insects move back to their winter host plants where eggs are again laid. There are many generations of this insect every year. The green peach aphid is reported from the Maritime Provinces, Quebec, Ontario and British Columbia.

CONTROL

Dusting or spraying the plants with nicotine sulphate as advised under the general control for aphids on page 14 will control this pest. Watch carefully for the first appearance of the insect and apply control measures early. Dust or spray the undersurfaces of the leaves thoroughly.

INSECTS ATTACKING CABBAGE, CAULIFLOWER, RADISH, TURNIP, ETC.

THE CABBAGE MAGGOT, *Hylemyia brassicae* Bouche

The cabbage maggot is the most serious pest of cabbages and cauliflowers in Canada to-day. The maggot attacks the roots and not only destroys the fibrous rootlets but bores into the tap root where winding, brownish tunnels are formed. Infested plants become stunted and on hot days wilt. Severely attacked plants turn yellow and die. The percentage of plants killed varies considerably in different years and in different fields but where growers neglect to apply control measures the loss is frequently most serious. Radishes are also frequently attacked and are rendered unfit for food by the presence of tunnels and larvæ in the flesh. The favourite host plants are cabbages, cauliflowers, radishes, turnips and other Cruciferæ.

The maggot is legless, white in colour and about $\frac{1}{4}$ of an inch long when full grown. The insect winters in the soil in the pupal stage near old infested plants. In the spring, about the time the European plums are coming into full bloom, the adult, which is a two-winged fly about the size of a housefly, emerges and in a few days commences to lay its eggs in the soil close to the stem of the plant. The eggs hatch in about 5 days and the maggots enter the soil to feed on the roots. This insect is found in all provinces of Canada.

CONTROL

The cabbage maggot can be effectively controlled by treating the young plants with a corrosive sublimate solution, used at the rate of 1 ounce to 10 gallons of water. As soon as the transplants are set out in the field, $\frac{1}{2}$ a cupful of this liquid is poured around the stem and on the soil at the base of the plant. Two subsequent applications should be made at intervals of a week. It is most important that the first application be made early enough. Do not delay the treatment until the first eggs have hatched, since by that time many maggots will be inside the plant. The correct time to make the first application is when the European plum is in full bloom. The corrosive sublimate may be applied from a watering can from which the "rose" or sprinkler has been removed and the spout partially plugged. For large fields of cabbages and cauliflowers the work will be hastened by using a barrel fitted with one or more leads of hose and mounted on a low waggon.

The corrosive sublimate should be dissolved in a small amount of hot water and then diluted to the correct amount. It should never be placed in metal containers since it will corrode and destroy them. Mix and dilute in wooden, glass or earthenware vessels. Corrosive sublimate is a deadly poison and should always be kept out of the reach of children and live stock.

To control the cabbage maggot in radishes water the plants as soon as they come up with corrosive sublimate in the above mentioned strength. A second treatment should be given in 4 or 5 days. Never treat radishes when they are nearly ready to use as there is danger of poisoning the consumer by so doing.

THE IMPORTED CABBAGE WORM, *Pieris rapae* L.

The imported cabbage worm annually does very serious damage to cabbage and cauliflower by feeding on the leaves and defacing the heads. Injury to the foliage usually takes the form of circular holes which frequently become so numerous as to practically destroy the leaves. The larva bores holes into the heads, making the latter unsightly and unfit for market and often spoiling them even for home consumption. The white heads of cauliflowers are frequently stained by the excrement of the caterpillars. In addition to cabbage and cauliflower, turnip, rape, Brussels sprouts, kale and radish are attacked.

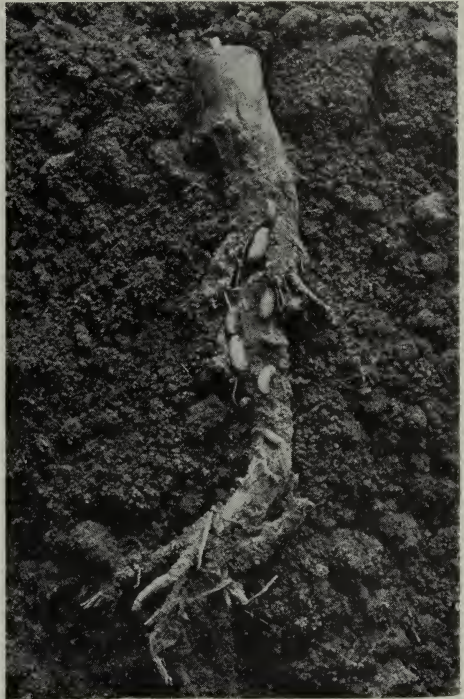


Fig. 36—Cabbage root maggot feeding on root of cabbage (after Gibson and Treherne).

The caterpillar when full grown is about $1\frac{1}{4}$ inches long and if examined closely is found to have an indistinct golden line down the back and to be densely clothed with short green hairs, giving it a velvety-green appearance. The insect hibernates in the chrysalis stage, attached to cabbage leaves, fences or buildings, by a fine silken girdle. The white butterflies emerge in May and in a few days deposit their yellowish eggs, usually singly, on the undersides of the leaves. Immediately on hatching the tiny larvæ begin feeding on the leaves of the host plant. Feeding is continued by subsequent broods during the entire summer. There are three generations, at least, in Ontario. The imported cabbage worm is present in all provinces of Canada.



Fig. 37—The imported cabbage worm and its work (after Gibson).

CONTROL

This insect can be controlled by the thorough dusting or spraying of the foliage with an arsenical as soon as the plants are seen to be injured. As the leaves are covered with a waxy film which causes liquids to collect in droplets and run off, dusting is recommended for best results. However, good control can be secured from the careful and liberal application of arsenicals in liquid form.

Eastern Canada.—In the spring when the caterpillars are first observed feeding on the leaves, dust the foliage thoroughly with arsenate of lead, using 1 part of the poison to 5 parts of hydrated lime. Arsenate of lime or Paris green may be substituted, in which case dilute the arsenate of lime with 8 parts of hydrated lime and the Paris green with 10 parts. If spraying is preferred use 2 pounds of arsenate of lead or $1\frac{1}{2}$ pounds of arsenate of lime or 1 pound of Paris green to 40 gallons of water. In the case of all sprays for use on cabbage or cauliflower plants add soap to the mixture at the rate of 2 pounds to 40 gallons.

Dust or spray the plants thoroughly covering both the upper and lower surfaces of the leaves. Put on the first application early and repeat every week or 10 days as needed.

If cauliflowers or cabbages, having holes eaten into the heads, require treatment shortly before being harvested, pyrethrum powder should be substituted for safety, as this material kills the insects readily and yet is not injurious to humans. Use pyrethrum powder at the rate of 1 ounce to 1 gallon of water and spray the plants at good pressure. Be sure that the pyrethrum is fresh when purchasing it from the dealer as it deteriorates in storage and loses much of its strength.

Prairie Provinces.—On the prairies dust the plants with either arsenate of lime, Paris green or white arsenic, mixing 1 part of any of these poisons with 10 parts of hydrated lime.

British Columbia.—Treatment as advised for Ontario is suitable for British Columbia conditions with the exception that if arsenical dusts are being used the poisons should all be diluted with, at least, double the amount of hydrated lime as was advised for use under Eastern Canada conditions.

THE CABBAGE LOOPER, *Autographa brassicae* Riley

Injury to cabbages and cauliflowers by the cabbage looper is practically identical with that caused by the imported cabbage worm. The leaves and heads are attacked and where the infestation is heavy cabbages and cauliflowers are rendered unfit for market. Besides the different cruciferous plants, lettuce, beets, peas, celery and other vegetable and flowering plants are often injured.



Fig. 38—Cabbage loopers feeding on cucumber leaf (after Gibson and Ross)

The caterpillar is pale green in colour with longitudinal white stripes down the sides and back. When it walks it raises the body in a peculiar looping motion which distinguishes it from the imported cabbage worm or the caterpillar of the diamond-back moth. It hibernates as a pupa in a silken cocoon which is attached to plant refuse. When the plants are being set out in the field the dark-brown moths appear and lay their circular, ridged eggs on the undersides of the leaves. The tiny caterpillars emerge in 4 to 5 days and commence feeding. There are three generations in Ontario. This insect is found in all provinces of Canada.

CONTROL

The caggage looper can be controlled by dusting or spraying with an arsenical, as advised for the imported cabbage worm.

THE DIAMOND-BACK MOTH, *Plutella maculipennis* Curtis

Caterpillars of the diamond-back moth are frequently found attacking the leaves of cabbages and allied plants where they eat small, circular holes through the lower epidermis. In normal years the injury is unimportant but under certain conditions quite extensive damage results. Cabbages, cauliflowers, Brussels sprouts and turnips are most frequently attacked while in some cases injury results to other members of the same plant family.

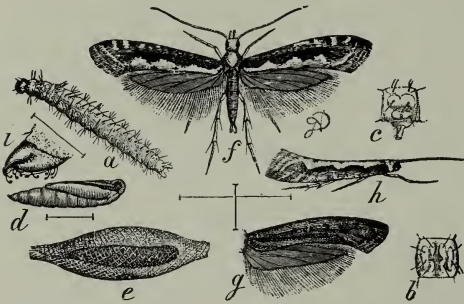


Fig. 39—The diamond-back moth; a, caterpillar; b, pupa; c, cocoon; f, moth enlarged (after Riley).

The caterpillar is yellowish-green and when full grown slightly less than $\frac{1}{2}$ an inch in length. It can be distinguished from the imported cabbage worm by the fact that it is not densely clothed with hairs and from the cabbage looper by the absence of white lines down the sides and back. The caterpillar is very active and when disturbed frequently

wriggles backwards off the leaf. The winter is passed in the adult stage, the tiny moth hiding beneath leaves on the ground and crawling away into protected situations. In the spring about the time the cabbage and cauliflower plants are set out in the field, the adult emerges and lays its eggs on the undersides of the leaves. Upon hatching, the caterpillars commence feeding and injury by subsequent broods can be seen throughout the entire season. The insect is found in every province of Canada.

CONTROL

Eastern Canada.—Follow control directions as advised for the imported cabbage worm.

Prairie Provinces.—Spray plants with a mixture composed of the following ingredients:—

Paris green.....	1 pound
Nicotine sulphate.....	$\frac{3}{8}$ pint
Laundry soap.....	$2\frac{1}{2}$ pounds
Water.....	40 gallons

Make first application as soon as damage is noticed and subsequent applications at intervals of a week to 10 days, as needed.

British Columbia.—Arsenical dusts or sprays as advised for the imported cabbage worm will control the diamond-back moth in British Columbia.

THE STRIPED FLEA BEETLE, *Phyllotreta vittata* Fab.

Leaves of very young turnips and radishes are often seen in the spring with small holes eaten through the tissue. This is the work of the striped flea beetle (see fig. 10, 1), a small insect which often escapes notice due to its habit of jumping off the plant when disturbed. The young of this beetle feeds on the roots of favorite food plants but does comparatively little harm. The striped flea beetle attacks such plants as turnips, radishes, cabbages, cauliflowers and a number of weeds belonging to the plant family Cruciferae.

In the autumn the beetle seeks shelter under refuse and debris lying in the fields and there passes the winter. With the coming of warm weather it emerges and commences feeding on available plants. At this time seed beds are often invaded and early planted radishes and turnips are injured in the field. Eggs are laid in the soil at the base of the host plants, the larvæ migrating to the roots as soon as they hatch. The adult is very small, black, and has a faint, wavy, yellow line down each side of the back. The insect is found in all provinces of the Dominion.

CONTROL

In the control of the striped flea beetle it is most important that operations be commenced as soon as the beetles appear on the plants in the spring. Delay often means serious injury. Pay special attention to the undersides of the leaves.

Eastern Canada.—Thorough spraying of infested plants with 4-6-40 Bordeaux mixture as described on page 15 will control this insect.

Prairie Provinces.—Dust the plants with the following mixture:—

Paris green.....	1 part
Copper carbonate.....	1 part
Hydrated lime.....	4 parts

Repeat applications every 6 or 7 days until the infestation is under control.

British Columbia.—Use 4-6-40 Bordeaux as advised for Eastern Canada. In British Columbia good results have also been obtained where the plants were treated with a 3 per cent nicotine dust. Instructions for the preparation of nicotine dusts will be found on page 9.

THE CABBAGE APHID, *Brevicoryne brassicae* L. and

THE TURNIP APHID, *Rhopalosiphum pseudobrassicae* Davis

Cabbage, cauliflower and turnip are occasionally attacked by the cabbage aphid and the turnip aphid which feed chiefly on the under surfaces of the leaves of these plants. They suck the juices out of the foliage causing a curling and wrinkling of the leaves with the formation of small pockets or cups in which the aphids hide. When the insects are numerous they collect in masses both on the upper and lower sides of the leaves and as a result of their excessive feeding

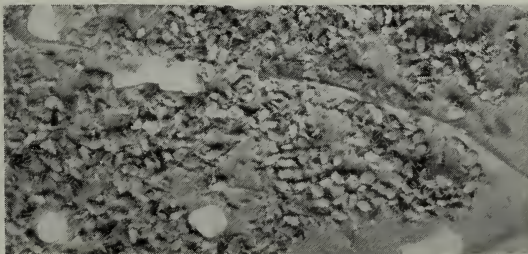


Fig. 40—Cabbage aphids clustered on underside of cabbage leaf (original, from photo by W. Robinson).

the foliage turns yellow and dies. The species can be distinguished by the fact that the cabbage aphid is bluish-gray in appearance and covered with a whitish powder while the turnip aphid is yellowish to brownish-yellow and naked. Fortunately, outbreaks of these aphids are rather rare and infested areas are usually scattered or patchy either in a field or throughout the district. Eggs laid on the stems and leaves in the autumn survive the winter and in the spring produce young to start a new infestation. Both of these species of aphids are found in every province of Canada.

CONTROL

Eastern Canada.—Dusting with nicotine sulphate as outlined on page 14 will control these insects. Spraying with the same material will assist but is not as effective as dusting. Infestations frequently start on a few isolated plants in a field and spread out from these. It is most important to treat such plants immediately as soon as they are seen and to stamp out the infestation by thoroughly destroying the first few insects. Ploughing under the refuse in infested fields in the fall is recommended, as it destroys many of the overwintering eggs.

Prairie Provinces.—Spray with nicotine sulphate and soap in the strength advised on page 14. Here also the infestation should be checked at the very outset, the insects on isolated plants being, if possible, totally destroyed.

British Columbia.—The control recommended for Eastern Canada holds also in British Columbia.

THE ZEBRA CATERPILLAR, *Ceramica picta* Harr.

Turnips and cabbages are sometimes attacked in the autumn by a rather striking-looking black and yellow larva, known as the zebra caterpillar. It feeds on the foliage and if abundant strips large areas. When young these insects cluster on the undersides of the leaves but as they increase in size the wandering habit develops and they scatter widely, feeding individually on their favourite plants. If abundant the zebra caterpillar attacks almost all varieties of vegetable and flowering plants but appears to have a preference for turnips, cabbages, cauliflowers and members of the cabbage family.



Fig. 41—Young zebra caterpillars feeding on cabbage leaf (original).

When full grown the larva is nearly 2 inches long. It is black in colour with yellow longitudinal bands running along the back and sides, which are connected up by fine yellow lines. The head and under part of the body is reddish. This insect pupates in the soil in autumn and passes the winter in that stage. The reddish-brown moth emerges in the spring and lays clusters of yellow eggs on the undersides of the leaves from which the tiny caterpillars hatch. There are two broods in Ontario. The caterpillars are not present every year but periodically appear in immense numbers to be quickly checked by insect parasites and diseases. The insect is distributed in all provinces of Canada.

CONTROL

The zebra caterpillar is very difficult to control after it has become partially or fully grown. Accordingly, it is most important that control measures be applied when the larvæ are young. Dusting the plants with Paris green, arsenate of lime or arsenate of lead will kill most of the insects. Dilute the Paris green with 10 parts of hydrated lime and the arsenate of lime or arsenate of lead with 5 or 6 parts of the same material. Cover all parts of the plant and apply in the morning or evening when the leaves are wet with dew. Two or three applications of dust at intervals of a week will be necessary to bring about control.

If spraying is preferred, use arsenate of lead at the rate of 2 pounds to 40 gallons of water to which has been added 2 or 3 pounds of laundry soap. Spraying is not as effective as dusting, since the leaves of the favourite host plants are waxy and difficulty will be experienced in getting an even distribution of the materials used.

THE RED TURNIP BEETLE, *Entomoscelis adonidis* Pallas

In Western Canada, cabbages, radishes, turnips and beans frequently have the leaves eaten by the larvæ and adults of a reddish coloured beetle about $\frac{1}{4}$ of an inch long, marked with 3 black stripes down the back and with a conspicuous black, triangular-shaped patch near the head. This is the red turnip beetle.



Fig. 42—The red turnip beetle, enlarged and natural size (original).

It passes the winter in the egg stage, the eggs being laid in loose masses under clods of earth. The larvæ when full grown are about $\frac{1}{2}$ an inch in length, black above and yellowish beneath. They pupate in the soil at a depth of about 1 inch. The adults appear in July and August. This species is confined chiefly to the Prairie Provinces and British Columbia.

CONTROL

Shallow cultivation in the autumn will bury many of the eggs and prevent the larvæ from emerging in the spring. When the larvæ and adults are plentiful, dusting the infested plants with arsenate of lime, 1 part and hydrated lime 10 parts, will kill many of them. Thorough work is essential to control. Repeated applications should be made if the insects persist in injuring the plants.

THE PEPPER GRASS BEETLE, *Galeruca externa* Say*

Cabbage and turnip are frequently injured by the feeding of the mature and immature stages of the pepper grass beetle. If the days are warm, feeding occurs only during the early morning and late afternoon, the larvæ and adults seeking shelter at the soil surface when the temperature reaches more than 85° F. Pepper grass and tumbling mustard are the favourite wild food plants, while under some circumstances perennial alyssum and *Arabis* spp. are attacked.



Fig. 43—The pepper grass beetle, enlarged and natural size (original).

The insect passes the winter in the egg stage, the eggs being laid in the autumn in the surface dust of the soil. The young larvæ appear about the second week of May. They develop very rapidly and early in June seek out a place in which to pupate. Adults begin to emerge during the third week of June and after feeding for a time go into aestivation. This extends over a period of about a month, when the beetles reappear. Feeding and mating follow. The eggs are laid over a period extending from the middle to the end of August. There is only one generation each year in Manitoba. This species is confined to the western provinces.

CONTROL

The adults can be controlled quite readily by treating them with a dust composed of 1 part of Paris green to 19 parts of low grade flour, distributed at the rate of at least 50 pounds per acre. Lime may be substituted for flour but is slightly less effective. This dust gives only partial control of the larvæ. Since pepper grass, tumbling mustard and species of *Arabis* are frequent hosts of the pepper grass beetle they should be either destroyed or dusted with the above mixture, when in the vicinity of the garden.

*Prepared from information supplied by Mr. R. H. Handford of the Dominion Entomological Laboratory, Treesbank, Manitoba.

THE CABBAGE FLEA BEETLE, *Phyllotreta albionica* Lec.

The cabbage flea beetle attacks a wide range of plants related to cabbage and turnip, most injury taking place in the spring when the seedlings are small. The insect eats small holes in the leaves and frequently kills the plants. Later in the season the injury continues and in years of heavy infestation even the leaves of large plants will be badly damaged. Although turnip and radish are the favourite hosts, cabbage, cauliflower, kale, Brussels sprouts and a wide variety of other vegetables and weeds are also attacked.

The adult is a shining, metallic-green beetle, measuring slightly over $\frac{1}{10}$ of an inch in length. It hibernates under dead leaves and rubbish, preferably in hedges and woodlots. The insect emerges in early spring and after mating

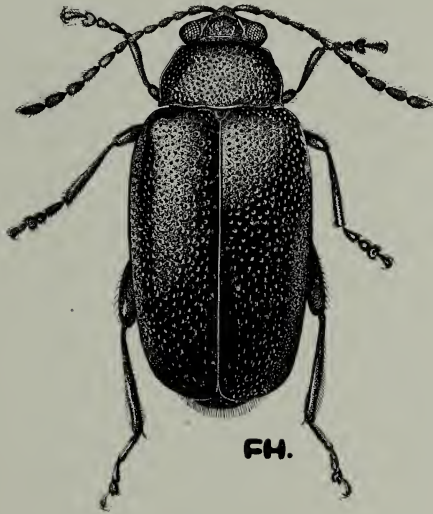


Fig. 44—The cabbage flea beetle, greatly enlarged (after Glendenning).

lays its eggs in the ground at the base of its food plant. The larvæ feed on the roots but cause little commercial damage. When mature they pupate in the soil, the adults emerging early in August. There appears to be only one generation annually. The insect is a pest of commercial importance only in Western Canada.

CONTROL

Dusting the beetles and plants with a 3 per cent nicotine dust will give good control. This should be done on a warm, calm day when the temperature in the shade registers 70° F. or over. Make 3 applications in the spring and 1 or 2 during the month of August, applying the first dust whenever the work of the beetles becomes noticeable. Use a good rotary or bellows hand duster and treat one row at a time working up against the sun at all times, so that the shadow of the operator does not frighten the insects away before the dust hits them. From 16 to 30 pounds per acre per application should be used, depending on the size of the plants. Directions for mixing this dust will be found on page 9.

INSECTS ATTACKING CARROT, PARSNIP AND CELERY

THE CARROT RUST FLY, *Psila rosae* Fab.

At time of thinning, carrots are frequently seen to be in a wilted and dying condition. If such plants are pulled and the tap root examined it will be found that the flesh is riddled with small reddish tunnels. These have been made by the maggot of the carrot rust fly. Badly infested carrots also have scars on the outside which have been formed by the feeding of the larva. Such injury occurs twice during the season, in June and again in September and October. Some damage is also caused by the maggot when the carrots are in storage. Carrots, parsnips and celery are attacked by this insect.



Fig. 45—Severe injury to young carrots by the carrot rust fly; natural size (original).

The larva of the carrot rust fly is a slender maggot, glistening-white in colour and, when full grown, slightly less than $\frac{1}{4}$ of an inch in length. In autumn it enters the soil and changes to a pupa in which state the winter is passed. The following spring, in late May, the adult fly emerges and lays its eggs, about the time the chokecherry trees come into bloom, in the soil immediately surrounding the carrot seedlings. When the eggs hatch the maggots work their way down to the end of the tap root and commence feeding. This species is essentially a pest of Eastern Canada.

CONTROL

The cheapest and most effective method of controlling this insect is to delay the planting of carrot seed until late June by which time the adults of the first generation of the carrot rust fly will have disappeared. Carrots planted as late as the end of June will mature successfully.

If early carrots are desired, however, the seed should be planted at the usual time, and late in May or about the first of June the seedlings treated with corrosive sublimate, used at the rate of 1 ounce to 10 gallons of water. The

liquid should be poured over the young plants in a liberal stream so that the soil on either side of the row is moistened to a distance of at least 2 inches. Two applications should be made, the first at the time when the wild cherries come into bloom, which is usually late in May or early in June, and the second a week later. Corrosive sublimate should be mixed only in glass, earthenware or wooden vessels, as it corrodes metals and in so doing loses much of its strength. It is a deadly poison and should be handled very carefully.

All carrots should be harvested as soon as mature in order that they may escape the attack of the flies of the second brood which are present in the field during late August and September.

THE PARSNIP WEBWORM, *Depressaria heracliana* DeG.

Parsnips and carrots grown for seed are frequently attacked by the parsnip webworm. This insect forms a web about the flower head and surrounding leaves and feeds within this tent until fully grown. As a result the blossoms are unable to open properly and no seeds are produced. Parsnip, carrot, celery and related wild plants are favoured hosts.



Fig. 46—Work of the parsnip webworm (original).

The adult is a small brownish-gray moth which passes the winter in sheltered situations, such as, beneath the bark of trees, in buildings, and other protected spots. Eggs are laid during the month of June; upon hatching the larvæ at once migrate to the unopened flower heads. When fully grown the caterpillar is less than 1 inch in length, yellowish-green in colour and covered with a large number of conspicuous black spots. It pupates in the hollow stem of the food plant. Moths appear in August and fly around for a time before seeking winter quarters. The insect is distributed in all provinces of Canada.

CONTROL

As these insects live and feed within a protective web, control is often very difficult. It is recommended, however, that infested plants be dusted with an arsenical mixture. Paris green and land plaster (1-20) or calcium arsenate and hydrated lime (1-10) will give best results. The dust should be forced into the webs where possible in order to cover the leaves upon which the larvæ are feeding. Cutting off and burning the larger webs before dusting will assist greatly in making the operation a success.

THE GREENHOUSE LEAF-TYER, *Phlyctaenia rubigalis* Guen.

Although primarily a greenhouse pest this leaf-tyer sometimes does very serious damage to celery growing under field conditions. The larva feeds on the underside of the leaf, chiefly, eating away the delicate green tissue. In many instances leaves are brought together and tied with fine silken threads, the caterpillar feeding inside the web. Frequently more than one larva will work on a single leaf. In certain sections of Ontario the greenhouse leaf-tyer has on occasions caused serious injury to celery. The insect attacks a great number of flowering plants, both in the greenhouse and in gardens. It also feeds on celery, sugar beet, cabbage, spinach, tobacco and a number of wild plants.



Fig. 47—Work of greenhouse leaf-tyer on celery (original, from photo by W. Robinson).

When full grown the larva measures about $\frac{3}{4}$ of an inch in length. It is dark green above with the sides and under surface somewhat paler. A white band runs lengthwise down the centre of the back with an indefinite dark green stripe inside it.

CONTROL

Work carried on recently by Ray Hutson in Michigan has shown that the greenhouse leaf-tyer can be controlled on celery by dusting or spraying infested plants with pyrethrum powder. Two applications within 30 minutes are necessary, as the larvæ feeding on the inside of the plants are not killed by the first treatment, but move out and are destroyed by the second. Treat the plants just as soon as the feeding of the insect becomes apparent and repeat as needed. In making the applications use plenty of pressure, forcing the dust or spray down into the centre of the plants so as to reach the caterpillars feeding in sheltered situations.

Only fresh and finely ground pyrethrum should be employed. In dusting, use 25 pounds of the powder per acre at each application. This may be diluted with equal parts of talc, chalk, bentonite or infusorial earth. If spraying is preferred, one of the many good pyrethrum sprays on the market should be secured and the table of dilutions on the can followed. Use 100 gallons of spray per acre at each application adding about 6 pounds of good laundry soap to that amount of material. This increases the spreading power of the spray and adds greatly to its effectiveness.

THE BLACK SWALLOWTAIL, *Papilio polyxenes* Fab.

The black swallowtail caterpillar attacks the foliage of celery, carrot, parsnip, etc., and in certain seasons does serious damage over restricted areas. The caterpillar when full grown is about 2 inches in length and is very striking in appearance. It is green in colour and each segment has a black band near the front margin enclosing 6 yellow spots. When disturbed it extrudes from the head 2 horn-like, fleshy protuberances which are supposed to have a repellent effect on its enemies. In addition to the above mentioned plants, parsley, caraway, fennel, sweet fennel and nearly all umbelliferous plants are attacked.

In Canada, the insect winters over as a chrysalid in the field, attached by a silken girdle to the remnants of the host plant. The adult which is a large,



Fig. 48—Caterpillars of black swallowtail (original).

black, swallowtail butterfly emerges in late May or June and lays its eggs singly on the uppersides of the leaves. These hatch in about 10 days and the young larvæ commence feeding immediately. They become full grown in from 3 to 4 weeks, depending to an extent on the season. This insect has been reported as doing serious damage in Eastern Canada only.

CONTROL

In small gardens where only a few specimens are present the caterpillars can be removed by hand and killed by dropping them in a vessel containing coal oil. Where the area infested is large and considerable injury is being caused, dust the plants with arsenate of lead or arsenate of lime. Use arsenate of lead at the rate of 1 part of the poison to 8 parts of hydrated lime. Arsenate of lime should be mixed with 10 times its weight of the carrier. Dust the plants thoroughly when the caterpillars are first noticed and repeat at intervals of a week or 10 days until all the insects are killed.

Foliage vegetables, when attacked, should be dusted with pyrethrum powder rather than with arsenicals, since it is non-toxic to humans. Dilute it in 4 times its weight of flour.

INSECTS ATTACKING CORN

THE EUROPEAN CORN BORER, *Pyrausta nubilalis* Hubn.

Corn, particularly sweet varieties, is frequently very seriously injured by the European corn borer. This insect attacks the stalks and cobs, boring its way into all parts of the plant. Heavily infested stalks become so weakened by the numerous tunnels that they break over and in this way entire fields of corn may be destroyed. The breaking down of the tassel is usually the first indication of the presence of the borer. Corn is practically its only host plant, although eggs are sometimes laid on oats, barley, gladioli, dahlias and some fleshy stemmed weeds.



Fig. 49—Cobs of sweet corn infested by the European corn borer (after Maheux and Crawford).

The corn borer when full grown is about 1 inch in length, whitish or brownish in colour and in some specimens slightly tinged with pink. The head is dark brown and there are numerous tiny spots on the body. The borer passes the winter in corn refuse in the field. With the coming of warm weather pupation takes place and towards the end of June the creamy-yellow or brownish moths appear. The adult lays its eggs in clusters on the undersides of the leaves. Soon after hatching the larvæ work their way into the plant and commence tunnelling. This species is found only in Eastern Canada.

CONTROL

The European corn borer can be controlled through the complete disposal of the corn crop remnants of one year, before the first of June of the next, either by feeding, ploughing under clean or by burning. Since the caterpillars hibernate in the corn refuse, the disposal of all remnants before the moths emerge in the spring will effectively rid any fields or farms so treated of the pest.

However, as the moths fly considerable distances, neighbouring, untreated fields serve as a source of reinfestation. For this reason every effort should be made to induce all growers in a district to co-operate in the disposal of corn refuse. The following control suggestions should be carefully followed:—

- (1) Cut all corn as low as possible in order to remove the bulk of the borers with the stalk.
- (2) Feed completely or burn all stalks harvested before June of the following year.
- (3) Uproot and burn all sweet corn stalks which cannot be conveniently ploughed under as soon as they have dried out.
- (4) Plough under all infested stubble and refuse in garden and field before June 1, so carefully that it is all completely covered.
- (5) Burn all corn refuse remaining about the farm in spring before June 1.

THE CORN EAR WORM, *Heliothis obsoleta* Fab.

The corn ear worm attacks chiefly the silk and ears of corn. The caterpillar works usually at the tip of the ears, eating the kernels down to the cob and leaving unsightly masses of moist castings. It has the habit of migrating from ear to ear and for this reason one larva will frequently destroy many ears. The corn ear worm is seldom a serious pest but occasionally severe outbreaks occur. The insect is a general feeder and attacks a wide range of field, garden and flowering plants as well as some weeds.

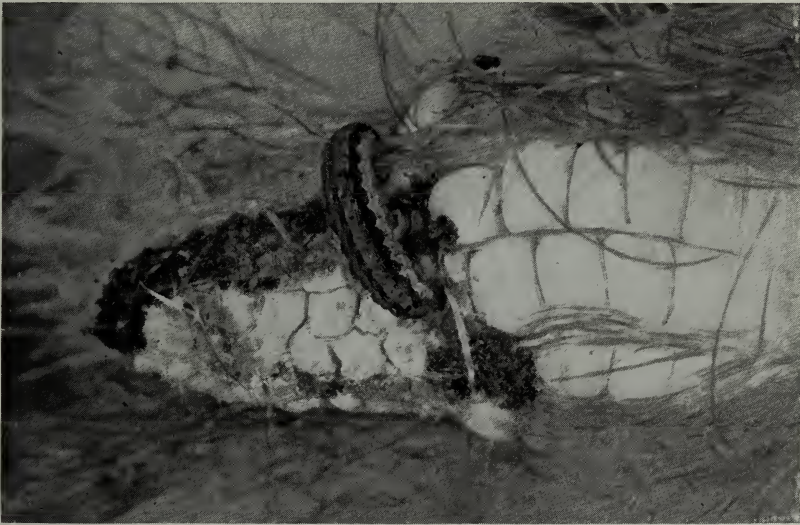


Fig. 50—The corn ear worm feeding on cob (original, from photo by P. C. Rollins).

When full grown the caterpillar is $1\frac{1}{2}$ inches long. It varies greatly in colour from light green to brown and usually has a longitudinal band along the side. As far as is known the corn ear worm is not able to over-winter successfully in Canada, new infestations arising each year from moths flying up from the Southern States. Females are capable of laying anywhere from 500 to 2,500 eggs, so it is not surprising that severe outbreaks sometimes are reported. The insect occurs periodically throughout Canada.

CONTROL

There is no very effective control known for this insect. Some entomologists advise dusting the silks of sweet corn with a 50-50 mixture of arsenate of lime and flowers of sulphur. This dust should be applied as soon as the silks appear and repeated applications made 3 or 4 times at 4 or 5 day intervals.

INSECTS ATTACKING CUCUMBER, MELON AND SQUASH

THE STRIPED CUCUMBER BEETLE, *Diabrotica vittata* Fab.

Cucumbers, melons and squash are frequently attacked by a small black and yellow striped beetle which feeds chiefly on the undersides of the leaves. This insect is known as the striped cucumber beetle. Most of the injury is done in the spring when the plants are very small and before the runners develop. When the insect is abundant many of the plants are killed. The larva attacks the roots but seldom causes any serious damage thereto. The favourite food plants are cucumbers, melons, squash, pumpkins, watermelons, etc. This insect feeds to some extent on beans, peas, corn and the blossoms of wild and cultivated plants.



Fig. 51—(1) Squash leaf injured by striped cucumber beetle (original); (2) striped cucumber beetle (original, from photo by W. Robinson).

The beetle is about $\frac{1}{5}$ of an inch in length with black head and yellow thorax and wing-covers. Three black, longitudinal stripes are present on the back. It spends the winter hidden away under rubbish, frequently in the field where feeding took place. Early in the spring it emerges and when the cucurbits appear they are quickly attacked. Eggs are laid in the soil surrounding the favourite food plants and when the larvæ emerge they migrate to the roots. This insect is found in all provinces of Canada.

CONTROL

As most of the injury by this insect takes place early in the season, young seedling cucumber, squash and melon plants should be watched carefully in the spring and upon the first sign of injury control measures should be applied. The insect feeds and hides on the under surface of the leaf, so that special attention should be given to that part of the plant both when watching for the beetles and when carrying out control operations.

When the insects are first noticed dust the plants thoroughly with arsenate of lime and gypsum, using 1 part of the poison to 20 parts of the carrier (by weight). If it is impossible to procure gypsum, hydrated lime may be substituted although this material is not so good. For this purpose use a hand duster equipped with a long delivery tube and a spoon-like lip at the end which enables the operator to cover the undersides of the leaves as well as the upper. Repeat the application whenever the beetles become numerous. A 3 per cent nicotine dust has given good control in the United States but is costly.

THE SQUASH BUG, *Anasa tristis* DeG.

The squash bug is primarily a pest of squash and pumpkins. It attacks the undersides of the leaves and by sucking out the juices causes light coloured areas to appear which subsequently turn brown and die. Occasionally entire plants are killed but usually only a leaf every here and there suffers. In severe infestations the leaves look as though they had been scorched by fire. Beside pumpkins and squash, cantaloup, melons, cucumbers and practically all members of the Cucurbitaceæ are attacked.

The squash bug is about $\frac{2}{3}$ of an inch in length and dark brown in colour. It passes the winter in the adult stage concealed in practically any protected situation. Refuse lying in the field forms an excellent and common hibernating

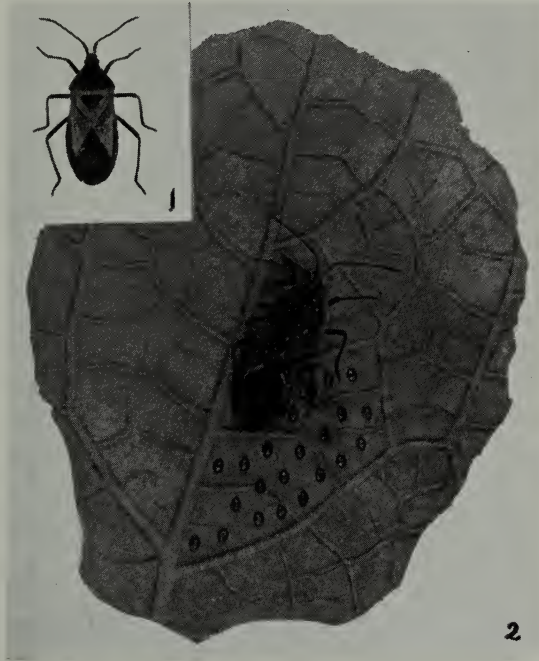


Fig. 52—(1) Adult squash bug (original, from photo by W. Robinson); (2) squash bug and eggs (original, from photo by P. C. Rollins).

medium. In June, the adult reappears and commences laying its eggs in clusters on the undersides of the leaves. The young nymphs at first feed in little groups but later scatter over the leaves. They mature very slowly, sometimes taking a month to reach maximum size. The insect is of economic importance only in parts of the provinces of Ontario and Quebec.

CONTROL

As this insect is rather difficult to control every effort should be made to reduce the infestation by cleaning up and burning plant refuse in the fall, since this will not only destroy many nymphs and adults adhering to the old vines but will, at the same time, remove possible places for hibernation.

In small plots hand picking of the egg masses and more mature insects is recommended. These can be destroyed by crushing or by dropping into coal oil. If shingles or flat boards are placed on the ground in the garden, squash bugs will collect beneath them at night and in the morning can be gathered and destroyed.

In large plots, dust the plants as well as the soil underneath them with a strong nicotine dust. For this purpose mix 6 to 8 pounds of nicotine sulphate with 94 to 92 pounds of hydrated lime, adopting the method suggested on page 9. Dust the plants thoroughly on a hot, calm day, covering both the upper and lower surfaces of the leaves. The ground beneath the plants should also be dusted to kill any bugs that drop off while the foliage is being treated. Thorough work is necessary for effective control.

THE MELON APHID, *Aphis gossypii* Glover

The melon aphid attacks the foliage of melons and cucumbers chiefly. Due to its habit of feeding on the undersides of the leaves the edges become curled downward and part of the foliage may become wilted or shrivelled. In severe infestations browning of the leaves takes place, many of the plants die and the crop is greatly reduced. The attack usually commences soon after the runners are formed. Some damage is also caused in greenhouses where the aphids frequently pass the winter.



Fig. 53—Melon aphid on leaf (original, from photo by W. Robinson).

These insects vary in colour from pale yellow to dark green or even black. In the open the winter is passed in the egg stage, the eggs being laid on a weed known as live-forever. Beside melons and cucumbers this species feeds also on strawberry, beet, spinach, bean and a number of weeds, including shepherd's purse, pepper grass, pigweed, etc. It has been reported as causing serious damage in the provinces of Ontario and Quebec.

CONTROL

The melon aphid can be controlled by dusting the infested plants thoroughly with a 2 per cent nicotine dust, prepared and used as described on pages 9 and 14.

INSECTS ATTACKING ONIONS

THE ONION MAGGOT, *Hylemyia antiqua* Meig.

Soon after the onions come up in spring many of them are attacked by a small, white maggot which bores into the lower part of the stem causing the plants to wilt and die. In years of heavy infestation as high as 90 per cent of the crop will be killed. Injury is most severe when the plants are small, although the attack continues throughout the entire summer and even into the autumn. This is the most serious enemy of onions in Canada. The onion maggot attacks onion plants only.



Fig. 54—Onions injured by the onion maggot (original).

The winter is passed in the pupal stage 2 or 3 inches below the surface of the soil in old onion beds. The adults, which are olive green, two-winged flies, emerge late in May and commence to deposit their white eggs in the soil at about the time the first apple blossoms burst into full bloom. The maggots as soon as they hatch bore into the base of the stem. When full-grown they measure about $\frac{3}{8}$ of an inch in length, are pure white in colour and devoid of legs. There are two generations and a partial third in the province of Ontario. This insect is distributed throughout Canada.

CONTROL

Eastern Canada.—Experimental work carried on at Ottawa has shown that the onion maggot can be controlled with a lubricating oil spray, first used by Compton in Illinois and prepared according to directions given on page 7. Either a light or medium lubricating oil of good grade should be used, preference being given to the latter. Four applications of this spray are applied, the first being made when the apple trees first come into bloom and subsequent sprays at intervals of a week. Careful and thorough spraying must be done and not only the plants but the soil between the rows should be covered with the liquid. At each application use 100-125 gallons of spray per acre, depending upon the size of the plants.

Prairie Provinces.—On the prairies the onion maggot can be effectively held in check by the use of corrosive sublimate. This material is used at the rate of 1 ounce to 10 gallons of water and is poured over the seedlings and soil surrounding them 4 times during the early part of the growing season. The first application should be made as soon as the first eggs are laid and later applications at weekly intervals. Use plenty of material, covering the small onion plants thoroughly and wetting the soil at their base for a distance of at least 2 inches on each side of the row. The liquid can be applied from a watering can with the spout partially plugged or, better still, a knapsack tank with a rubber hose leading out from the bottom and reaching down almost to the ground. It is most important to apply the first treatment before any of the eggs have hatched. Corrosive sublimate should be mixed only in glass, wooden or earthenware vessels and should be kept out of the reach of children and stock, as it is a deadly poison.

British Columbia.—Use corrosive sublimate in this province.

THE ONION THRIPS, *Thrips tabaci* Lind.

The onion thrips is an exceedingly minute insect which feeds upon the leaves of onions. By means of its tiny jaws or mandibles it rasps the tissues and laps up the liberated plant juices. Tiny whitish or silvery spots or streaks appear where the thrips has been feeding which is characteristic of the insect. The damage is seldom serious in cool, damp seasons but in dry, hot summers this insect may cause very severe injury. When fields are heavily infested the plants first take on a whitish or silvery appearance. The leaves then wilt and die as though struck by blight. A large number of different vegetables are attacked although onions are the favourite food plant.

The onion thrips is light yellow to brown in colour, about $\frac{1}{25}$ of an inch in length and possesses 4 tiny wings fringed with delicate hairs. It passes the winter in the adult stage hidden in piles of refuse in the field. With the coming of warm weather the adult emerges and lays its eggs in the tissue of onion leaves. The nymphs are wingless and pale yellow in colour. They feed on the foliage, causing the same type of injury as the adults. There are many generations each season. The onion thrips is found throughout Canada.



Fig. 55—Onion leaves injured by onion thrips (original, from photo by W. Robinson).

CONTROL

As these insects are rather difficult to control by artificial means every effort should be made along the lines of prevention. Clean up all refuse in the onion field in the autumn, burning or burying the tops and bulbs to insure the destruction of all thrips. In spring, burn over headlands or grass lands bordering the onion field as this will kill a large number of the insects which have hibernated in these situations. It is also a wise precaution to plant onions a considerable distance from alfalfa fields, or from any vegetation which might provide good wintering quarters.

As soon as the thrips appear on the plants, spray with a strong solution of nicotine sulphate and soap, using $\frac{1}{2}$ pint of the tobacco extract to 40 gallons of water. Dissolve 4 pounds of laundry soap in hot water and add this to the mixture. In spraying use good pressure, in order that the spray will be forced down into the axils of the leaves. Cover the plants thoroughly, so that all parts will be well soaked with spray. Use 75 to 125 gallons per acre at each spraying, depending on the size of the plants. Repeat the application in a week to 10 days and give additional treatments whenever the thrips again become numerous. Thorough and careful work is necessary to hold these insects in check.

INSECTS ATTACKING PEAS

THE PEA MOTH, *Laspeyresia nigricana* Steph.

When shelling peas one often finds many of them defaced by the feeding scars of this insect. Sometimes every pea in the pod will be injured while in other cases only a seed every here and there will be attacked. The caterpillar bores its way into the peas, making irregular holes in their sides and frequently spinning a web around and over the injured peas. In some sections of the country the insect is a very serious pest, practically prohibiting the sale of table peas. Field and garden peas are the only food plants known.



Fig. 56—Larva of pea moth and injured peas (original, from photo by S. H. Payne).

This insect passes the winter in the larval stage enclosed in a silken case just beneath the ground surface. The mature caterpillar is yellowish-white in colour and about $\frac{1}{2}$ an inch in length. In the spring it changes to a pupa and late in June the small brownish moths emerge. Eggs are laid on the sepals or small leaves at the base of the pod and when the caterpillars hatch they bore into the pod and attack the peas. There is only one generation each year. This insect is a commercial pest only in Eastern Canada.

CONTROL

The pea moth is rather difficult to control but a few general recommendations may be made which will assist greatly in reducing the infestation.

(1) Where possible, practise crop rotation, planting seed only on ground where peas have not been grown, at least, during the previous season.

(2) Plough ground deeply in the late autumn after the pea vines have been removed.

(3) Destroy vines and old pods, by burning just as soon as the peas begin to get hard and ripe.

(4) Plant either very early or late maturing varieties.

(5) The use of arsenicals has not proved of any value and so spraying or dusting is not advised against this insect.

THE PEA APHID, *Illinoia pisi* Kalt.

About the time pea vines are coming into blossom they are sometimes attacked by a small green insect known as the pea aphid. In seasons favourable to the development of the insect serious damage often occurs. The blooms, leaves and stems become literally covered with masses of aphids which suck the juice from the plants, causing them to turn yellow and dry up before the seed has matured. Even when the insects are not sufficiently abundant actually to kill the vines the quality of the peas is affected. Garden and sweet peas, field peas, clover, alfalfa and other members of the legume family are attacked.



Fig. 57—Pea aphid feeding on leaf (original, from photo by P. C. Rollins).

The insect passes the winter in the egg stage, the eggs being laid on clover, alfalfa and related plants. In the spring the newly emerged nymphs feed for some time on the winter host plant but finally winged forms appear and a migration to peas takes place. Feeding and development continues on the summer host until the peas commence to ripen when a return migration to clover commences. Eggs are again laid on these plants in the autumn. This insect is a pest of economic importance in all provinces of Canada.

CONTROL

Eastern Canada.—Under garden conditions, where peas are planted in definite rows, the pea aphid can be controlled by dusting the plants as soon as the insects appear with a $2\frac{1}{2}$ -3 per cent nicotine dust. Directions for mixing

and applying this are given on pages 9 and 14. Very thorough work is necessary and the dust must be liberally applied on a hot, calm day when the temperature registers 75° F. or higher. Spraying with nicotine sulphate, used at the rate of $\frac{1}{2}$ a pint to 40 gallons of water may be substituted but is not so effective (see page 14).

Plant peas as early as is practical and see that the field is located as far from clover stands as can be arranged, since the aphids spread from these plants to peas in the spring to start new infestations.

Prairie Provinces.—Spray plants with nicotine sulphate, $\frac{1}{2}$ pint to 40 gallons of water to which has been added 2 or 3 pounds of laundry soap as soon as the aphids appear in the spring.

British Columbia.—Follow directions as advised for Eastern Canada. In British Columbia planting of peas on a large scale is not advised after a mild winter, since aphids are always abundant following such a season.

THE PEA WEEVIL, *Mylabris pisorum* L.

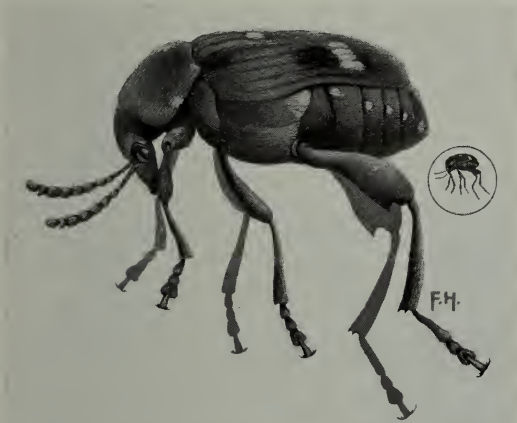


Fig. 58—The pea weevil, enlarged and natural size (after Gibson and Twinn).

Peas are frequently infested by a small brownish beetle, about $\frac{1}{5}$ of an inch in length, which lives in a little chamber inside the seed made by the feeding of the grub. This is the pea weevil. In certain parts of Canada it causes very serious injury by either destroying the germinating power of the seed or by so reducing the vitality of the pea that only weak and sickly plants are produced. Fortunately this insect does not feed on any other garden plant.

The adult weevil passes the winter either inside the seed in storage, in barns or granaries, or in sheltered situations in the field. Emergence from winter quarters comes when the peas are forming pods and the young larvae

takes place about the time the peas are laid. The female lays her yellow eggs on the outside of the seed, and on hatching bore their way inside and infest the peas. Never more than one larva is found in a seed. Pupation takes place in the cavity eaten out by the larva. There is only one generation each year and development never takes place in stored seed as is the case with the bean weevil. The insect has been found in stored peas in all provinces of Canada.

CONTROL

Infested peas should never be used for seed without previous treatment. If weevils are found to be present in even a small percentage of the peas they should be fumigated with carbon bisulphide. Full directions for this operation are given in the section dealing with the bean weevil on page 32.

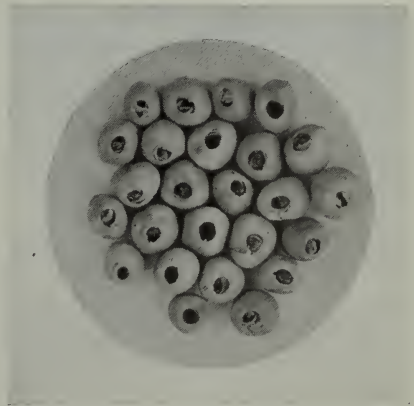


Fig. 59—Peas infested with pea weevil (after Gibson and Twinn).

INSECTS ATTACKING POTATOES, TOMATOES AND EGGPLANTS

THE COLORADO POTATO BEETLE, *Leptinotarsa decemlineata* Say

The potato beetle is so well known as to need little introduction. It is entirely a foliage feeder, both the adult and larva attacking the leaves. Feeding commences in the spring as soon as the plants come up, since the beetles usually emerge before the plants appear. The greater part of the damage is done by the larvæ, however, and in Eastern Canada unsprayed plots are usually entirely destroyed. In addition to potatoes, tomatoes, eggplant, tobacco and nightshade are sometimes injured.

The beetle passes the winter in the soil, chiefly in potato fields, at a depth of about six inches. Emergence takes place in late May and practically as soon as the plants appear egg-laying commences. The eggs, which are yellowish-orange in colour, are laid in clusters on the undersides of the leaves. They hatch in about a week, when the small larvæ begin feeding. The potato beetle is found in every province of the Dominion.

CONTROL

Eastern Canada.—This insect can be easily and satisfactorily controlled by spraying or dusting the vines with an arsenical. Since potatoes are frequently attacked by fungous diseases it is customary to dilute the poisons in Bordeaux mixture rather than water, in this way controlling both insects and diseases in the one operation. Spraying is perhaps the most generally accepted method of applying the insecticide when fighting this insect, although dusting is almost as effective. Control measures should be undertaken covering the upper and lower surfaces of the leaves. If spraying, use 100-120 gallons of spray per acre at each application, but 50 pounds of dust should be used where dusting is practised.



Fig. 60—The Colorado potato beetle;
hair line indicates natural size
(after Gibson).

as soon as the first eggs hatch; the operation should not be delayed until the plants commence to show signs of injury. Make the first application early and repeat when necessary. Treatments are usually made at intervals of 10 days to 2 weeks, depending on weather conditions and the seriousness of the attack, and 5 or 6 applications during the season are commonly given. Spray or dust thoroughly,

When spraying use either 2 pounds of arsenate of lead, $1\frac{1}{2}$ pounds of arsenate of lime or $\frac{3}{4}$ of a pound of Paris green to 40 gallons of 4-6-40 Bordeaux mixture. Directions for making Bordeaux mixture will be found on page 8. If the arsenicals are diluted in water instead of Bordeaux, 2 or 3 pounds of hydrated lime should be added when Paris green is used, since this prevents any possibility of burning.

The best dust to use is one composed of 12 pounds of dehydrated copper sulphate, 8 pounds of arsenate of lime and 80 pounds of hydrated lime. This dust has a fungicidal value as well as being a good insecticide. If fungous diseases are not a factor of importance a dust made up of 8 pounds of arsenate of lime and 92 pounds of hydrated lime will give good results against the potato beetle.

Prairie Provinces.—On the prairies a dust composed of 1 part of arsenate of lime or Paris green to 10 parts of hydrated lime is recommended. In areas where there is no dew, white arsenic can be substituted for arsenate of lime and used at the same strength. In Alberta, arsenite of zinc has given excellent

control when diluted with hydrated lime or flour, at the rate of 1 to 10. Sprays of arsenate of lime or Paris green diluted in water as recommended for Eastern Canada can also be used with good results.

British Columbia.—Spray or dust with any of the arsenicals as advised for Eastern Canada.

THE POTATO FLEA BEETLE, *Epitrix cucumeris* Harr.

The leaves of potatoes are frequently attacked by the potato flea beetle which eats very small circular holes through the lower surface. When numerous the leaves dry out and turn brown and the plant is seriously weakened. The larva of this species usually does little harm. It feeds chiefly on the roots and tubers of the vines and sometimes causes little pimples or warts to arise on the potatoes in the autumn. Potatoes and tomatoes are the favorite food plants although a rather wide range of vegetables and weeds are attacked to a limited extent.

The adult is black with brownish legs. (See fig. 10, 2). It is extremely small, measuring about $\frac{1}{16}$ of an inch in length. It spends the winter hidden away under rubbish and leaves in or near the old potato fields. In May it emerges and feeds for a time on weeds until the potatoes appear, when it migrates to them. The eggs are laid singly in the soil beneath potato vines. Upon hatching the young work their way down to the roots as has already been mentioned. There is only one generation a year in Canada. The potato flea beetle is found in all provinces of the Dominion.

CONTROL

Eastern Canada.—These insects are easily controlled by spraying the foliage with 4-6-40 Bordeaux mixture as described on page 15. Make the first application as soon as the insects are seen and repeat in 10-12 days or when necessary.

Prairie Provinces.—Treat the plants when the injury first becomes apparent with a dust composed as follows:—

Paris green.....	1 part
Copper carbonate.....	1 part
Hydrated lime.....	4 parts

Repeat the application as soon as the work of the beetles is again noticed.

British Columbia.—Spraying with Bordeaux mixture alone acts as a deterrent. Paris green or arsenate of lead may be added to the Bordeaux to make it more effective, or these may be used alone; 1 pound of arsenate of lead or $\frac{1}{2}$ pound of Paris green and 4 ounces of casein should be used to each 40 gallons of water. In the latter case, $\frac{1}{2}$ pound of freshly slaked lime should be added. Arsenate of lead (powder) or Paris green may also be used dry and should be



Fig. 61.—Typical injury to potato foliage by the potato flea beetle (after Gibson).

mixed with hydrated lime at the rate of 1 pound of the poison to 20 pounds of hydrated lime, and the mixture dusted over the plants in the early morning when the dew is on. In the case of tomato plants, protection may be secured by the same treatment or by dipping the whole plant except the roots, before planting, in a mixture of 1 pound of arsenate of lead in 10 gallons of water.

THE WESTERN POTATO FLEA BEETLE, *Epitrix subcrinita* Lec.

In British Columbia potatoes are attacked by the western potato flea beetle. This insect in the adult stage causes typical flea beetle injury to the leaves by eating small circular holes through the lower epidermis. Serious damage is caused when the infestation is heavy. The larva feeds on the roots and tubers of the plant and frequently bores into the latter. Potato, tomato, eggplant, pepper and beans are the favorite food plants, although some weeds are also attacked, particularly during the early part of the season.

Like most flea beetles, this insect hibernates in the adult stage in sheltered situations. The adult beetle is bronzy-brown in colour and emerges in the spring, first feeding on weeds but later migrating to cultivated plants. The eggs are laid in the soil and the young larvæ feed as described above. Adults appear again in late July from pupæ formed in the soil. There are two generations each year on the western coast.

CONTROL

Spraying infested plants with Bordeaux mixture as described on page 15 deters most of the beetles. Some authors recommend the addition of an arsenical, such as arsenate of lead, 1 pound to 40 gallons, or Paris green $\frac{1}{2}$ pound to 40 gallons, to the spray. (See control as advised for potato flea beetle, on page 65.)

THE POTATO LEAFHOPPER, *Empoasca fabae* Harr.

This insect is of importance, not so much as a result of the direct injury caused by its feeding, but because it injects into potato leaves a toxin which is the cause of a condition known as "hopperburn." Leaves attacked by potato leafhopper adults and nymphs turn yellow at the tip and along the edges. The margins later turn brown and become curled upward and inward. If the damage is general death of the plant usually results. This is the condition known as "hopperburn" which can be caused by the feeding of all stages of this insect. In addition to potatoes, it attacks apple, beans, tomatoes, clover, alfalfa and a wide range of cultivated plants and weeds.

The adult is a slender, pale, green bug about $\frac{1}{8}$ of an inch in length. It winters over in refuse, under leaves and in dense grass and weeds, and emerges in spring to lay its eggs in the tissue of its favorite host plant. The eggs hatch in from 1 to 2 weeks and the little nymphs commence feeding on the lower surfaces of the leaves. Both adults and nymphs have sucking mouthparts and pierce the tissues to extract their food. The insect is present in all provinces but is important from an economic standpoint on vegetables, only in Eastern Canada.

CONTROL

Use 4-6-40 Bordeaux as advised for flea beetles on page 15. Spray particularly the under side of the leaves, making the first application when the leafhoppers commence to attack the plants. Repeated spraying should be given at 10 day intervals as needed.



Fig. 62—The potato leaf hopper; (1) adults; (2) nymphs; (3) potato vines destroyed; treated plot in background (original, from photo by W. Robinson).

THE POTATO APHID, *Illinoia solanifolia* Ashm.

The potato aphid causes serious injury to potato vines during certain seasons by clustering on the leaves and tender shoots and sucking out the juice. Leaves which are heavily infested turn yellow and in severe cases die. Whole fields have been so affected in years favourable to the development of the insect. The potato aphid is also instrumental in the dissemination of two of our most important potato diseases and this is probably more serious than the injury caused directly by its feeding. It attacks potato, tomato, eggplant, pepper, pea, bean, apple, turnip and a wide variety of other wild and cultivated plants.

The potato aphid is a small, green, soft bodied insect which feeds in clusters chiefly on the under surfaces of the leaves. Although possessing rather long legs it moves very slowly when disturbed. During the summer it feeds for the most part on the potato but as autumn approaches it migrates to roses and passes the winter there in the egg stage. In the spring young nymphs are produced. These feed for a time on the rose but later winged forms appear and a migration back to the potato and other favoured plants takes place. The insect is distributed in all the provinces of Canada.

CONTROL

Dust the vines with a 2 per cent nicotine dust when the first aphids are seen, using a trailer behind the duster. Directions for the preparation and application of this material are given on pages 9 and 14. Pay particular attention to the undersides of the leaves as the aphids are found there chiefly. Spraying with nicotine sulphate at the rate of 1 pint to 100 gallons of water, to which is added 5 pounds of laundry soap, will give fair control but is not as satisfactory as dusting. A second or third application at intervals of a week to 10 days may be necessary if the infestation is heavy.

BLISTER BEETLES

These insects are sometimes found in considerable numbers feeding on potato vines. Their work resembles that of the Colorado potato beetle but in the case of blister beetles all the damage is done by the adults. There are three common species in Ontario of which the most important is the black blister beetle (*Epicauta pennsylvanica* DeG.). In Western Canada, Nuttall's blister beetle (*Lytta nuttalli* Say) is one of the most injurious species. Although potato is the favourite host, other cultivated and wild plants are sometimes attacked.

Blister beetles in general are rather large, slender beetles and vary in colour according to the species. They are usually soft bodied and have the head well set off from the abdomen. The eggs are laid in the soil and after hatching the young have the peculiar habit of feeding on grasshopper eggs. When fully grown they pupate in the ground, the adults appearing from June to September. Although annually present in the East, these insects only occasionally do serious damage. In the West, however, they are more common and are looked upon as a more troublesome pest. Blister beetles of one species or another are found in every province of Canada.



Fig. 63—The black blister beetle; hair line indicates natural size (after Gibson).

CONTROL

Eastern Canada.—Dusting or spraying infested plants with an arsenical is recommended when the insects become sufficiently numerous to cause commercial injury. If dusting is preferred use arsenate of lead or arsenate of lime diluted with hydrated lime at the rate of 1 part to 5 parts of the former or 1 part to 7 parts of the latter. When spraying, use 2 pounds of arsenate of lead or $1\frac{1}{2}$ pounds of arsenate of lime to each 40 gallons of water.

Sodium fluosilicate is recommended in the United States for the control of blister beetles. This poison is diluted with equal parts of hydrated lime and thoroughly dusted over the plants as soon as their feeding is noticed. It is supposed to act more quickly than arsenicals and to be equally, if not more, effective.

Prairie Provinces.—In Manitoba and Saskatchewan, blister beetles are controlled by dusting the infested plants with arsenate of lime, used at the rate of 1 part of the poison to 10 parts of hydrated lime. In Alberta, spraying the plants with arsenate of lime 1 pound, nicotine sulphate $\frac{3}{8}$ of a pint, soap $2\frac{1}{2}$ pounds to 40 gallons is recommended.

British Columbia.—Use remedies as advised for Eastern Canada.

THE POTATO STEM BORER, *Gortyna micacea* Esp.

The stems of potato, rhubarb, corn and other vegetables and weeds are frequently attacked by a boring caterpillar which causes the plants to wilt and die. It is known as the potato stem borer. When full-grown the caterpillar is about $1\frac{3}{4}$ inches long, pinkish-white in colour with a brown head capsule. It enters the stem at the ground level and tunnels through the centre. Unfortunately, the borer does not confine its attention to one plant but migrates from one to another, thus greatly increasing the amount of injury.

The winter is passed in the egg stage, the eggs being laid on grasses in the vicinity of gardens. Hatching takes place in June and the larvæ seek out some suitable fleshy-stemmed weed and enter by boring a small hole through the stem. Adults appear in August and the eggs are laid toward the end of that month. There is only one generation each season. This insect is generally distributed throughout Canada.



Fig. 64—Young corn plants destroyed by the potato stem borer (after Gibson).

CONTROL

(1) Destroy all weeds during the latter part of August and September, when the moths are laying their eggs. This applies not only to weeds growing in the garden but also to those present in surrounding wasteland.

(2) Practise crop rotation, following susceptible crops by others less frequently attacked, such as turnips, cabbages, etc.

(3) Pull and destroy plants as soon as injury is noticed, since this prevents the insects from migrating from host to host and multiplying the amount of injury.

THE TOBACCO WORM, *Phlegethontius quinquemaculata* Haw.

Tomatoes are sometimes attacked by a very large green caterpillar which feeds on the leaves and when abundant defoliates the plants. This is the "tobacco worm." It is about 4 inches long when full grown, dark green in colour with white, V-shaped markings on the sides and a prominent horn-like appendage projecting from the hind end. It is not abundant every year, but in certain seasons is sufficiently numerous to cause considerable losses to tomato growers. It does not confine its attack solely to this plant, but feeds also on tobacco, eggplant, potato and pepper.

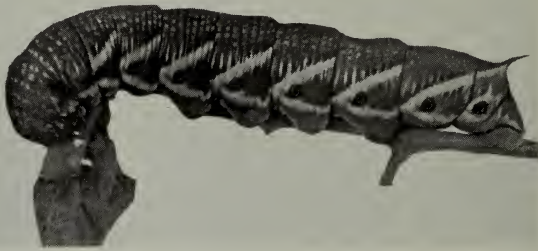


Fig. 65—The tobacco worm (original, from photo by P. C. Rollins).

The insect hibernates in the pupal stage in the soil. The adults, which are hawk moths, appear in June and lay their yellowish eggs, singly, on the under sides of the leaves. These hatch in about a week and the larvæ commence feeding at once. They become full grown in 3 or 4 weeks and then enter the ground to pupate in an earthen cell. These caterpillars are of economic importance only in the provinces of Ontario and Quebec.

CONTROL

In small plots hand picking the large caterpillars is advised, the insects being killed by dropping them into a vessel containing a mixture of coal oil and water.

Where "tobacco worms" are causing commercial injury in large fields, spraying or dusting the plants should be practised. If spraying, use 3 pounds of lead arsenate or $1\frac{1}{2}$ pounds of calcium arsenate or 1 pound of Paris green to 40 gallons of water. When either of the last two poisons are used add 4 or 5 pounds of hydrated lime to the spray to counteract any burning effect. Should dusting be preferred, the lead arsenate should be diluted with 3 times its weight of hydrated lime, the arsenate of lime with 4 times its weight or the Paris green with 6 times its weight of the same material. One application is usually sufficient to bring about control.

ACKNOWLEDGMENTS

In the preparation of this bulletin full use has been made of many bulletins and text books dealing with the subject of vegetable insects and their control which have been published in different parts of Canada and the United States. In this connection special reference should be made of the publications of Mr. Arthur Gibson, Dr. W. H. Brittain and Messrs. Georges Maheux, Lawson Caesar, A. V. Mitchener and Max Ruhmann.

The controls outlined for the insects in the Prairie Provinces and British Columbia have, in general, been recommended as in effective use by officers of the Entomological Branch in these parts of Canada and I would like to thank most heartily Messrs. Norman Criddle, K. M. King, H. L. Seamans, E. R. Buckell, W. Downes and R. Glendenning for their co-operation. In checking the distribution and local importance of the insects included in the bulletin much assistance was rendered by the officers in charge of the different entomological laboratories throughout Canada. It is a pleasure to acknowledge this service. Photographs illustrating stages and work of certain of the species discussed were very kindly supplied by the laboratories at Annapolis Royal, N.S., Strathroy, Vineland Station and Chatham, Ontario, all of which are acknowledged individually wherever used. During the preparation of the bulletin much very valuable assistance and advice was given by Mr. H. G. Crawford, Chief of the Division of Field Crop and Garden Insects, which was greatly appreciated by the author. I am indebted to Mr. George E. Grattan, Secretary of the Advisory Board under the Agricultural Pests Control Act, who prepared the list of antidotes for use in treatment necessitated by possible poisoning arising in connection with the use of the insecticides included in the bulletin. My thanks are also due Mr. F. C. Hennessey, Branch Artist, for the preparation of the cover design and drawings of five adult insects and for general assistance in connection with the illustrations.

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LIST OF PUBLICATIONS

The following publications of the Department of Agriculture relating to insects are available on application to the Director of Publicity, Department of Agriculture, Ottawa:—

The Chinch Bug in Ontario.....	Circular No. 3
The White-marked Tussock Moth and its Control.....	Circular No. 11

NEW SERIES

The Fruit Tree Leaf-roller and its Control in British Columbia.....	Circular No. 10
The Beet Webworm.....	Circular No. 14
The Control of Forest Tent Caterpillars in the Prairie Provinces.....	Circular No. 19
The Apple Curculio and its Control in Quebec.....	Circular No. 36
Two Orchard Scale Insects, the San Jose Scale and the Oyster Shell Scale.....	Circular No. 37
Mosquito Control in Canada.....	Circular No. 62
The Round-headed Apple-tree Borer and its Control.....	Circular No. 73
The Lecanium Scale.....	Circular No. 77
The European Red Mite.....	Circular No. 39
The Cherry Fruit Worm.....	Circular No. 79
The Strawberry Root Weevil.....	Pamphlet No. 5
The Western Wheat-stem Sawfly and its Control.....	Pamphlet No. 6
Directions for Collecting and Preserving Insects.....	Pamphlet No. 14
Aphids or Plant Lice.....	Pamphlet No. 31
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Methods of Protection from Mosquitoes, Black Flies and Similar Pests of the Forest.....	Pamphlet No. 55
The Pear Psylla and its Control.....	Pamphlet No. 66
The Red-backed Cutworm and its Control in the Prairie Provinces.....	Pamphlet No. 69
The Cabbage Flea Beetle and its Control in British Columbia.....	Pamphlet No. 80
The Western Cedar Borer.....	Pamphlet No. 94
The Control of Grasshoppers in Canada East of the Rocky mountains.....	Pamphlet No. 146
Household Insects and Their Control.....	Bulletin No. 112
The European Corn Borer.....	(Hanger)

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ANTIDOTES

SEND FOR A DOCTOR

ARSENIC—ARSENATE OF LEAD, ARSENATE OF LIME, PARIS GREEN, WHITE ARSENIC, SODIUM ARSENITE.

Cause the patient to vomit by giving a tablespoonful of mustard in a glass of warm water. Then give the patient milk and raw eggs, sweet oil or salad oil, flour and water and lime water. Flaxseed tea may be given if convenient.

COPPER—COPPER SULPHATE, COPPER CARBONATE, BLUESTONE.

Cause the patient to vomit by giving a tablespoonful of mustard in a glass of warm water. Then give half a teaspoonful of baking soda in water, then the whites of three or four eggs, milk and sweet or salad oil.

FLUORIDES—SODIUM FLUORIDE, SODIUM FLUOSILICATE.

Cause the patient to vomit by giving a glass of warm water containing a tablespoonfull of mustard. Then give the patient lime water or a 1 per cent solution of calcium chloride.

CORROSIVE SUBLIMATE.

Give the patient all the milk and white of raw eggs he can take. Do not make him vomit.

TOBACCO EXTRACTS—NICOTINE SULPHATE, etc.

Cause the patient to vomit by giving a glass of warm water containing a tablespoonful of mustard. Put the patient to bed and give strong hot tea or coffee to drink. Apply heat to the arms and legs, and keep the patient warm.